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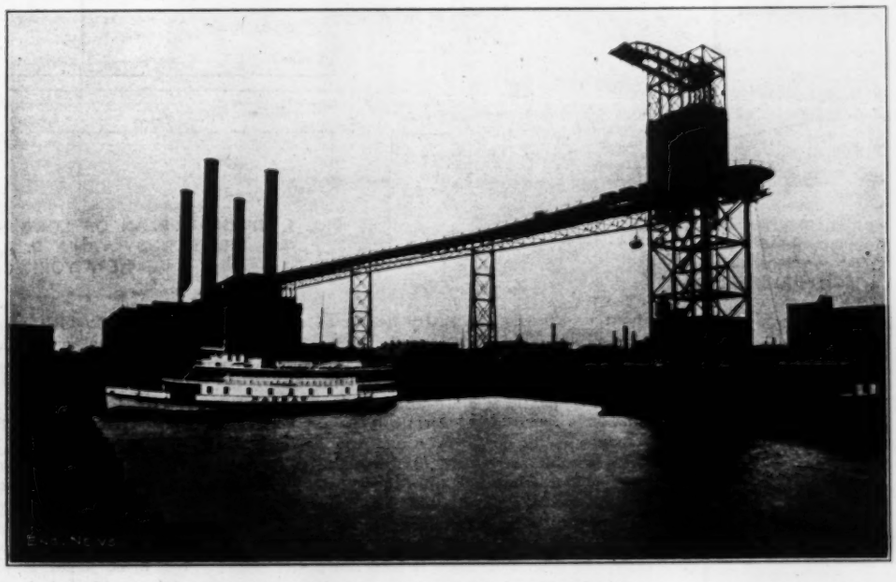
THE PENNSYLVANIA R. R. EXTENSION TO NEW YORK AND LONG ISLAND: STRUCTURAL DETAILS OF LONG ISLAND POWER STATION.

The Pennsylvania R. R. extension to New York and Long Island involves besides the tunnel lines and the great passenger station in Manhattan, already described in Engineering News, a complete electrical power generating and distribution system of large capacity. To secure reliability of service and convenient distribution it was decided to build two power stations, one in New Jersey and one on Long Island. This division made it possible, furthermore, more conveniently to put in operation the suburban lines of the Long Island R. R., already planned for electric traction without waiting for the completion of the tunnel lines and the stations and terminals in New Jersey and New York. In few words, then, the task has been, while going ahead with the tunnel and terminal work, to rush the completion of the Long Island power station and apply electric traction to the Long Island R. R. suburban lines as fast as they could be equipped. In our issue of Nov. 2, 1905, we outlined the proposed electric traction lines of the Long Island R. R. and gave a general description of the power plant and sub-stations and of the distribution system and train equipment provided for their operation. The present article supplements this general outline with a description in detail of the novel and the more important structural features of the power station.



GENERAL VIEW OF LONG ISLAND POWER-HOUSE OF PENNSYLVANIA R. R. EXTENSION TO NEW YORK CITY.

Power-House Construction.

The location selected for the Long Island power-house is in Long Island City, close to the East River front and adjacent to the Long Island R. R. freight yards; specifically it is a rectangular block extending 200 ft. north and south on Front St. and West Ave., parallel to the water front and 500 ft. along Third and Fourth Sts. The location and lay-out of the plant are shown by Fig. 1. In reference to this general plan it may be explained that at the time the design was undertaken the extent of electrification in sight was such as to necessitate a station capacity of 50,000 KW. As the largest size of steam turbines and generators that had then been standarized was 5,500 KW., this size was adopted as the unit basis of the station. The adopted design of station occupying the entire block 200 × 500 ft. permits the installation of 14 of these units, or an aggregate of 105,000 E. HP. For the initial load to be placed upon the station it was decided that three 5,500 KW. units would suffice. The power-house was, therefore, constructed only a portion of its ultimate size, namely, 200 ft. wide and 250 ft. long for an equipment of six 5,500 KW units and two 2,500 KW. units for lighting the tunnels. This is the present Long Island City power plant now to be described.

SUBSTRUCTURE.

The substructure of the present station comprises the foundations for the main building and for the coal and ash handling plant and the intake and overflow flumes for the condenser water.

FOUNDATIONS.—The entire site of the power plant was made ground. Borings showed from 10 to 15 ft. of loose fill overlying successive strata of clay, sand and gravel, with rock at a depth of from 35 to 60 ft. For the main power-house piles 25 to 40 ft. long spaced 30 ins. on centers in both directions were driven over the entire area and capped with a continuous footing of concrete. It was found that the proper distribution of loads through the footing to the piles required a depth of 6½ ft. of concrete. The level of the top of the footing being established 3½ ft. above mean high tide, this depth of concrete enabled the piles to be cut off 2½ ft. below mean high tide, with their tops bedded 6 ins. into the footing. Underneath the four stacks, however, the depth of footing is increased to 8 ft. 6 ins., the piles being cut off 2 ft. lower down. A load of 12 tons per pile was assumed in designing the footing.

The reasons for adopting a continuous footing on piles for a foundation carrying isolated columns and machines are stated by the engineers as follows:

> The advantages of the monolith are, that future loadings can be adjusted to suit future conditions should it ever be necessary to conform to progress in the design as well as possible changes in the location of apparatus as the state of the art advances. Uniformity of settlement is also assured, which is never certain in isolated foundations until settlement has actually taken place. The pile construction has an additional advantage in holding the underlying earth in position to assist in carrying the load, as well as directly assisting the load to pass through bed rock as most of the piles are driven to hard bottom. A comparative study of the monolithic and disconnected type of foundation showed that the monolithic type was much less expensive. The use of individual piers would have necessitated a large amount of extra excavation, which, if utilized afterwards as a basement underneath the building would have had to be waterproofed and artificially drained because the mean tide level approaches so nearly the level of the street.

The foundations for the coal tower are located in water on a sloping bed of rock covered with soft material. The soft material was dredged to a level bed 2 ft. above the highest rock level and a timber crib was sunk onto this bed. The crib is 46 ft. wide and 50 ft. long, constructed of 12 × 12-in. timbers, with two transverse and two longitudinal vertical partitions tying the walls together and dividing the interior into compartments. After being sunk the crib was banked around with rip-rap and the four corner compartments were filled with piles driven to rock All spaces inside the crib were filled with rip-rap and the whole was capped by two layers of 6 × 12-in. timbers. On this capping were constructed the concrete piers supporting the lower legs.

CONDENSER WATER FLUMES.—The flume for the condenser intake and the overflow flume directly above it are integral with the building foundations; their location is shown by the plan Fig. 1. They are constructed of concrete, reinforced where the conditions call for such additional strength, and are provided with the usual screens, ice fenders, etc. The novelty of the flume construction lies in the arrangement at the shore end. At a point 50 ft. from the bulkhead the tunnels separate, the overflow tunnel passing at an angle of approximately 45° with the center line of the intake. The intersection of the overflow with the bulkhead is oblique, with the object in view of producing a long, slow flow at the outlet. The spillway of the flume is

formed up into a dam, the object of the dam being twofold: first, to insure a water seal on the discharge pipes of the condenser circulating system, and second, to spread the warm water on the surface of the harbor to prevent its mixing with the condensing water entering through the intake. This separation of the outer ends of the flumes also enables the rack and screen chambers of the intake to be made of ample size and readily accessible.

DETAILS OF CONSTRUCTION METHODS.—The construction of the foundations and the flumes was generally straightforward work. Some trouble was had with water in the flume building, but none that was not readily overcome by the ordinary cofferdam and sheet piling processes of work. For the foundations spruce piles were used and were driven practically to refusal with a 2,000-lb. hammer falling 18 to 20 ft. The concrete was mixed by machine using a Ransome mixer. As the concrete had to be placed in freezing weather, provision was made for heating the sand and stone piles by means of a hot air furnace, burning waste lumber, the heat being distributed by means of an 18-in. pipe running through each pile of material, and so situated that the material shoveled into the cars was taken from a section of the pile traversed by the pipe, so that it was sure to be well thawed out. The water used for mixing the concrete was also heated with steam, from a 20-HP. steam boiler of the vertical type.

After mixing, the concrete was dumped into large two-wheel buggies of about 6 cu. ft. capacity which were pushed to the point where the concrete was required over a set of staging having a grade toward the destination, thus facilitating the speed at which material was delivered. The material was dumped from the plank runways directly onto the work.

The concrete was mixed in proportions of 1—2½—5, very wet, and required very little ramming. Although the work was done during an unusually cold winter, the precautions taken sufficed to prevent trouble from freezing. The entire block of concrete required for the monolithic cap and the flumes, was about 18,000 cu. yds. The first concrete was placed on Jan. 27, 1904. Under favorable conditions the mixing capacity of the plant was as high as 100 cu. yds. of concrete per hour. On one occasion 57 men, working eight hours, placed 716 cu. yds. of concrete, or about 90 cu. yds. per hour for a whole day.

SUPERSTRUCTURE.

The superstructure of the power-house calls for brief mention only; the general appearance of the structure is shown by the accompanying perspective view and the plan arrangement is indicated by Fig. 1. The over-all dimensions of the present building are 200 ft. by 262 ft. outside measurement. The boiler-house is 103 ft. wide inside, the engine room 66 ft., and the electrical galleries 25 ft. wide. The boiler-house proper is 82 ft. high to the top of the parapet. The coal pocket enclosure, superimposed on the boiler-house, is 60 ft. wide, and its parapet is 118 ft. high. The engine room is 70 ft. high, to the top of the parapet.

The first floor of the boiler-house is 16 ft. above the basement, and the second floor of the boiler room is 35 ft. above the first floor. In the engine house, the engine room floor is 23 ft. 6 ins. above the basement, and thence to the roof trusses the height is about 40 ft. in the clear. This is a much lower engine room than is commonly met with in power stations of this size, the saving in head room being due to the adoption of the horizontal type of steam turbine, which enables economy in vertical space required as well as in the floor area. Like all large power stations of modern construction the building consists of steel framework.

COAL AND ASH HANDLING PLANT.

The coal and ash handling plant is an especial feature of the power station; it is so designed that the handling of the fuel is mechanical from the time it is lifted from the barges until the ashes are discharged into railway cars for removal. The essential features of the plant are indicated in the perspective view. The completed structure may be said to consist of three parts, the coal hoisting tower, the bridge supporting the cable railway, and the ash bin structure which is so arranged that it forms a part of one of the piers of the cable railway bridge. This level bridge is 107 ft. above the dock, and is about two-thirds the entire height of the tower, whose top is 170 ft. above the dock. The upper third of the tower, extending above the level of the cable railway, carries the hoisting boom, the receiving hopper, coal crushing and weighing apparatus and the cable railway machinery.

Between the coal tower and the power-house is the viaduct structure carrying the cable railway, which continues into the power-house directly over the W-shaped coal bunkers above the topmost series of boilers. Special dump cars receive the coal from the crusher hoppers, as shown by Fig. 2, convey it into the power-house and discharge into the bunkers.

The ash bin is directly across Front St., Fig. 1, from the power-house, and is built of brickwork and steel, as shown by the vertical section, Fig. 3. Ashes are delivered to the bin through a bridge at an elevation of 69 ft. above the street by means of a telpherage system, which hoists and transports the ash cans from the boiler room basement up to the level of this bridge and thence over into the tower, where the contents are dumped into the bin. The bottom of the bin is 20 ft. above the railway track that runs through the base of the tower, and the ashes are discharged through dumping gates into gondola cars standing on this track. The capacity of the bin is 300 tons.

POWER-HOUSE EQUIPMENT.

Beyond a statement of its general arrangement and character, the power-house equipment cannot be described, since to go fully into the multitudinous details would exceed reasonable space. In general, the equipment may be divided into (1) the coal handling plant already separately described; (2) the steam generating plant of boilers with their necessary water supply, pumps, furnaces, flues, economizers, stacks and ash handling plant; (3) the steam piping plant and its various auxiliaries, and (4) the electrical plant. The relative arrangement of these several parts is clearly indicated by Fig. 1.

SUBDIVISION OF EQUIPMENT.—The system of design was followed in laying out the equipment of the power station. The battery of 32 boilers is divided into eight groups of four boilers each, four of these groups being on the first floor and four directly over them on the second floor of the boiler-house. The four boilers of each group stand opposite each other across an alley or firing space, and are separate as regards economizer, flue, and stack connections, but their steam connections are made up so as to form them into a group for the purpose of unit subdivision. That is to say, the four boilers at the west end of the plant on the first floor, on both sides of the alley, are piped to one manifold, which is connected to a vertical header, and the four boilers directly above them on the second floor are piped in the same manner to the same header, the two groups of four constituting the first unit group at the west end of the boiler room. This group is amply sufficient to furnish steam to the two 2,500-KW. lighting units, which will eventually constitute the first unit subdivision at the west end of the engine room. The second groups of four boilers on the first and second floors are piped together in like manner, so that they can, as one group, supply steam to the first 5,500-KW. turbo generator. These main groups of boilers are piped together by a cross-connecting header, which is to be considered as an equalizer, rather than as a large main into which all boilers feed and from which all engines take steam, which is the most usual layout of power station steam piping. Although this subdivision into unit plants may or may not be availed of by the operating force, it nevertheless constitutes a systematic and uniform scheme of development, favoring the duplication of the bends, valves and other pipe details, thereby rendering construction economical.

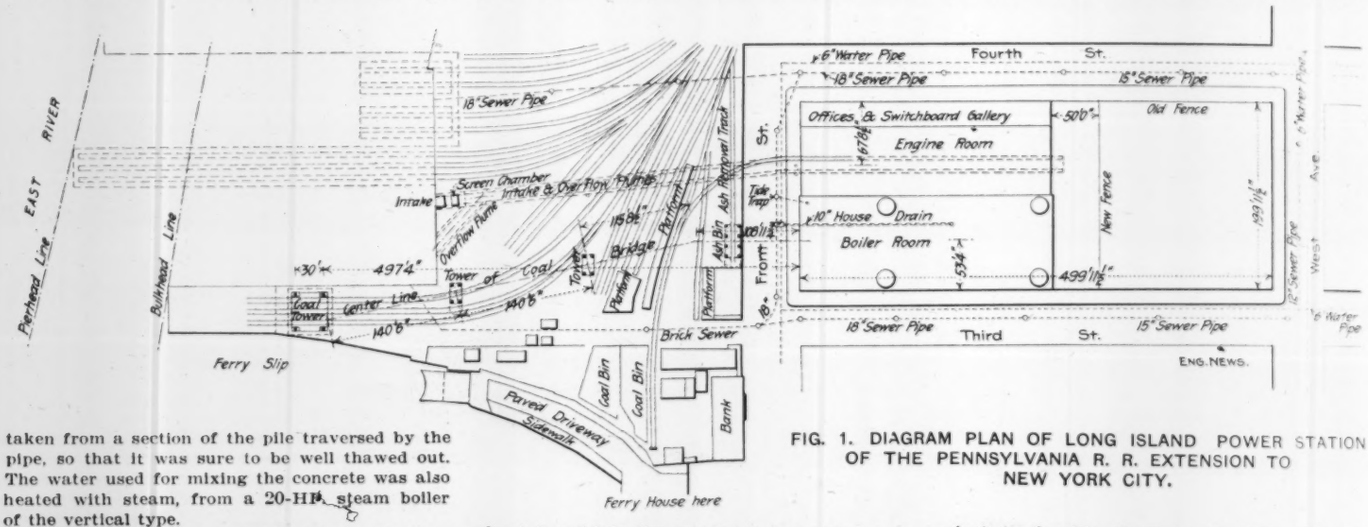


FIG. 1. DIAGRAM PLAN OF LONG ISLAND POWER STATION OF THE PENNSYLVANIA R. R. EXTENSION TO NEW YORK CITY.

DESCRIPTION OF EQUIPMENT.—The equipment of both boiler and engine rooms consists for the most part of standard machines well known to engineers and needs only brief description.

The 32 boilers are of the Babcock & Wilcox water tube type; they are designed for a working pressure of 200 lbs. per sq. in. Each boiler has 5,243 sq. ft. of water heating surface and is supplied with an internal superheater capable of superheating the steam 200° F. when the boiler is operating at 200 lbs. pressure. A Roney mechanical stoker fires each boiler. Each double battery of four boilers is provided with an economizer by which the hot gases are so reduced in temperature that they enter the stack at about 350° F.

For the initial equipment three main generating units have been installed, consisting of steam turbines direct-connected to three-phase 11,000 volt generators of the revolving field type. The turbines are of the Westinghouse-Parsons single-flow type, rated to develop 5,500 KW. at 175 lbs. steam pressure, and 27½ ins. vacuum, running at 750 r. p. m. The generators are each guaranteed to deliver 280 amperes per terminal at 11,000 volts, and 80 to 100% power factor for a space of 24 hours continuously, with a rise in temperature not to exceed 35° C.; and a 50% greater current for two hours with a rise not exceeding 55° C. These separate sources are provided for exciting the fields of the main generators, viz., two steam-driven excitors, one motor-driven excitor and a storage battery. The construction of these auxiliaries and of the switch board apparatus is such as is common in large power plants and will not be described. Two features of the power-house equipment not yet mentioned are the water supply to the boilers and the condensers and their operation.

WATER SUPPLY SYSTEM.—The following considerations were uppermost in the design of the general supply system: First, to provide a reliable and sufficient means for supplying water to the plant at all times and under all conditions of load; second, to provide a reserve capacity in tanks for the storage of the quantities of water sufficient to meet emergency conditions; third, to provide means for collecting in this storage tank the water of condensation from the turbines, so as to use it over again in the boilers, and fourth, to provide a means of automatically supplying "make-up" water to make good the various waste occurring in the boiler, turbine and condenser system from leakage or otherwise, and to provide suitable means for heating this "make-up" water for a long enough time and up to a sufficiently high temperature to drive off as a vapor or to precipitate such deleterious gases and solids as it might naturally carry, in order to prevent injurious chemical action upon the valve seats, condenser tubes and other important elements in the main steam plant.

Water is taken from the mains of the Montauk Water Co., two of whose service mains are connected to an 18-in. main supplying the power-house. In order to be sure of having a reserve on this supply, there was built adjacent to the Long Island R. R. yard, at a distance of about 2,700 ft. from the power station, the nearest available site, a standpipe 40 ft. in diameter and 80 ft. high, which is connected into this 18-in. main and under ordinary circumstances kept full. From the 18-in. main, which runs along Front St., parallel to the south wall of the building, two 14-in. branches are carried into the building, each branch having two 10-in meters in multiple with suitable by-pass connections. A third water connection of the same size is tapped from the same main at the southeast corner of the power station, making a shorter connection for the water piping that will be installed at that end of the building, when the entire plant is completed. This is now blanked off. There are also two independent cross connections between this 18-in. supply line and the city water system, one on either side of the power station, to further supplement the main power-house supply in case of accident to the Montauk Water Co.'s pipe line. The two 14-in. branches are joined together inside of the building forming a loop, which in case of emergency can supply directly the suction for the feed pumps, although under normal conditions this water is only used as needed for "make-up" water to be added to the water condensation which is returned from the surface condensers.

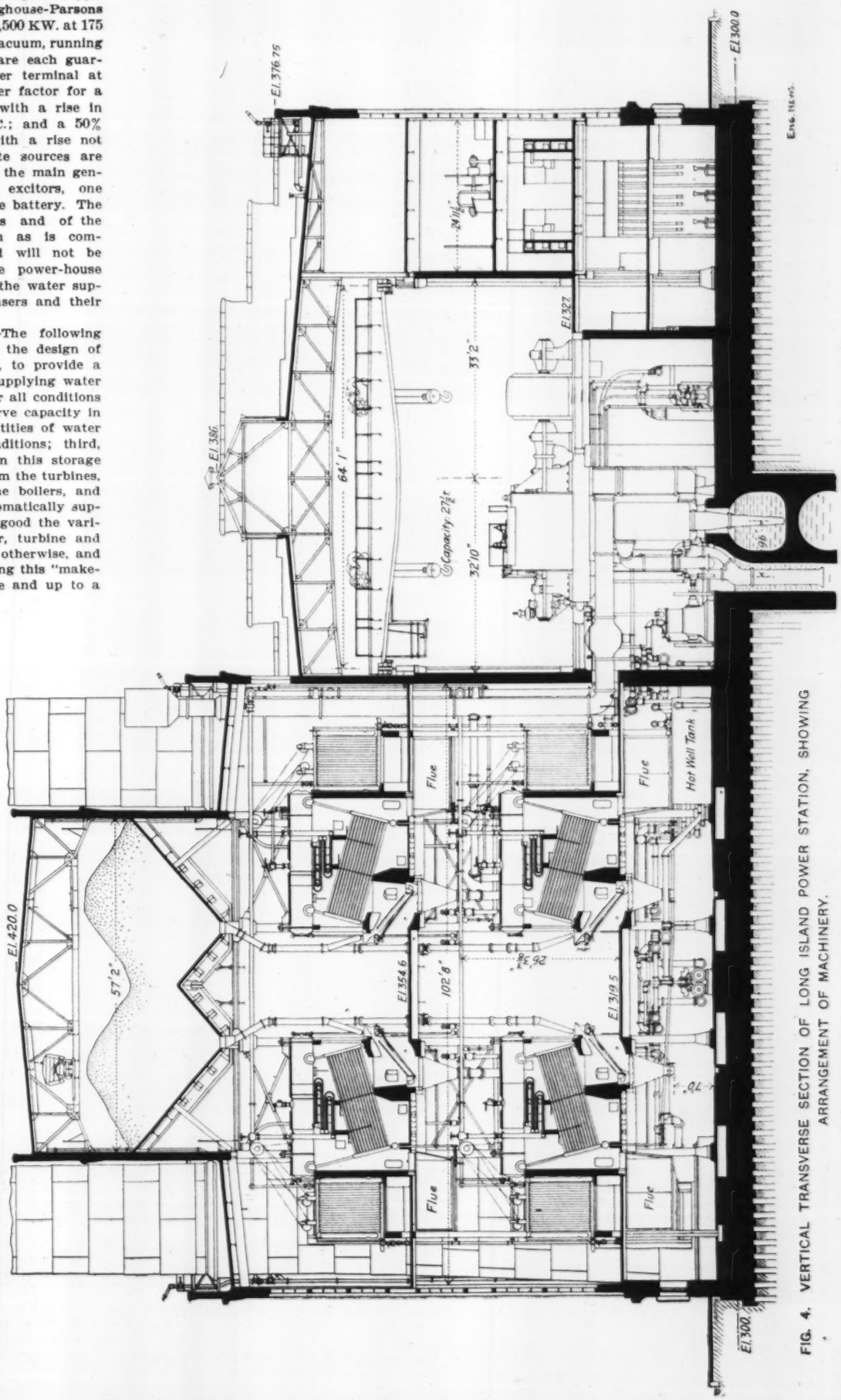


FIG. 4. VERTICAL TRANSVERSE SECTION OF LONG ISLAND POWER STATION, SHOWING ARRANGEMENT OF MACHINERY.

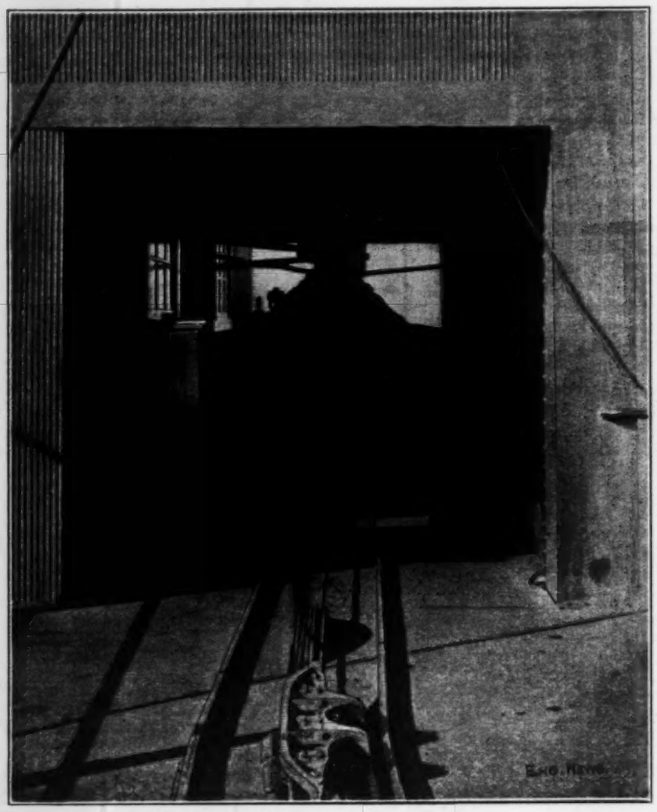


FIG. 2. VIEW SHOWING CAR RECEIVING COAL FROM TOWER HOPPERS FOR TRANSPORTATION TO BOILER ROOM BUNKERS.

One of the advantages in employing steam turbines is that the steam if condensed in a surface condenser is absolutely free from lubricating oil and can be used over and over again without injury to the boilers. This consideration was influential in determining the employment of surface condensers in this station, as the expense of purchasing the bulk of feed water from an outside source is thereby avoided. The major part of the boiler supply is therefore derived from the hot wells receiving the discharge from the surface condensers. For each generator unit two hot wells are provided in the form of steel tanks 18 ft. 4 ins. by 18 ft. 5 ins., and 6 ft. 6 ins. deep, to which the water of condensation is pumped. Although each unit has its own pair of hot wells, they may all be connected together. The water in these tanks is kept at a constant level by the addition of the "make-up" water supplied as described above, this being added automatically through the agency of a pump governor actuated by a float valve in the tank.

The make-up water is taken from the outside supply mains, above mentioned, and the pipe connections are so arranged that if desired it may first be used for cooling purposes around the building, such as in jacketed bearings, whence it passes to the open heater. Otherwise, it goes directly from the mains to the open heater, which is a cylindrical Cochrane feed-water heater and purifier, made by the Harrison Safety Boiler Works. This heater is 8 ft. in diameter and 15 ft. long, and utilizes exhaust steam from the double-acting auxiliary engines and reciprocating pumps in various parts of the building. It has sufficient capacity to heat feed-water for 15,000-HP. of boilers from 40° to 205° F.

It was made purposely large in order to insure a comparatively slow circulation of the make-up water through it, so that it would have ample time to throw off the carbon dioxide and other injurious substances in solution which would attack the valve seats and the tubes in economizers and condensers. The make-up water is likely to run from 10 to 15% of the entire water consumption of the plant. The heater is really more of a purifier than a heater. The arrangement was designed with this particular object in view. The Westinghouse single-acting engines driving auxiliary machinery do not send their exhaust steam to this heater on account of the particles of crank case oil that may work into the exhaust, but the ordinary cylinder oil in the exhaust of the pumps and double-acting engines is extracted by allowing the steam to run at a very low velocity through a comparatively large pipe before reaching the heater, and thence into a 26-in. Cochrane oil separator, by which means it is effectually extracted.

By the course of treatment above outlined, the purity of the water in the steam in all parts of the system is insured, resulting in a marked decrease in corrosion and leakage in all parts of the plant, with a corresponding reduction in operating expense and depreciation. For instance, the wear and tear on both water and vacuum pumps is appreciably reduced by reason of the lower speed made possible by the absence of leakage. The seats of the high-pressure steam valves being integral with the bodies, the corrosion of them would be a serious matter, but it is believed that corrosion can be absolutely prevented by eliminating from the feed-water the gaseous as well as the solid impurities in the above manner.

CONDENSERS.—A separate condenser is provided for each turbine of the counter-current surface type, built by the Alberger Condenser Co., and having 20,000 sq. ft. of cooling surface, consisting of seamless drawn brass tubes of No. 18 S. W. G., and 1-in. outside diameter.

The condenser is placed in a large arched opening made in the turbine foundation. There is thus a marked saving in space made possible by the horizontal type of turbine, for it enables the entire condensing plant, consisting of condenser, circulating pump, dry air pump and hot well pump to be compactly grouped within and about the base of the foundation.

The exhaust trunk is of cast iron, rectangular in section, well ribbed up on the outside. The outboard exhaust passes over the top of the condenser, through a 36-in. relief valve, to an independent vertical 36-in. exhaust pipe passing up through the roof behind the boilers.

The exhaust steam enters the condenser at the bottom. The dry air pump exhausts the vapor from the top and the water of condensation is collected from the bottom by the hot well pump. The circulating water enters the tubes at the top, makes three passes, and is discharged from the bottom of the condenser into the overflow flume directly underneath.

The intake flume is underneath the overflow, and access to its contents is made possible by a well extending past the outflow flume down to the intake flume, this being shown in sectional elevation in Fig. 4. Condensing water is lifted from this well by a 24-in. double suction centrifugal pump made by the Morris Machine Works, capable of pumping 20,000 gallons of salt water per minute against a head of 20 ft. Each pump is driven by a 12 × 24 × 12-in. Westinghouse compound engine direct-connected to it. The engines are able to develop 175 HP. at 175 lbs. steam pressure at 225 r. p. m., running non-condensing.

The condensed steam is drawn from the bottom of each condenser and discharged [illegible] tanks in the boiler room basemen[t] centrifugal pump direct-connected [illegible] 220-volt direct current motor ru[n] r. p. m. A by-pass arrangement [illegible] flow flume is provided for discharg[ing] densed steam directly into the flu[me] The relation of the hot well tanks [illegible] feeding system has already been ou[t]

Vacuum is maintained in each [condenser] by means of a horizontal [two]-stage dry vacuum pump, with [governor] and automatic governor on the st[eam] positive valve motion on the vacu[um] vacuum cylinders and heads are [water] The steam cylinders are 10 and [16]-ameter, and the pump cylinders [24]-diameter, with a 24-in. stroke, a[nd] speed is 100 r. p. m. They are [built] Alberger Condenser Co.

CONDENSER TUBE PROTECTI[ON] what unusual feature has been i[n] this station to prevent the serious[ly] usually occurring where salt wat[er] circulation of surface condensers. [It] universal experience that more or [less]

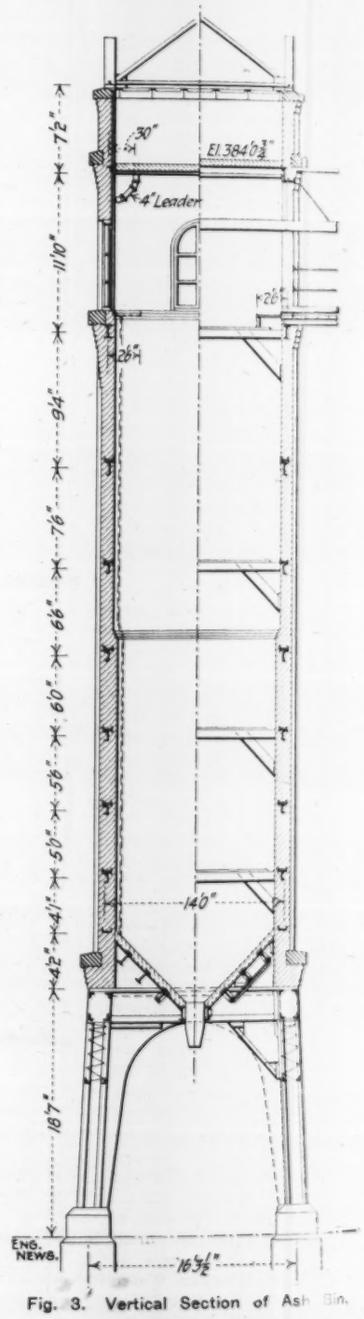


Fig. 3. Vertical Section of Ash [Bin].

action takes place in any event at the expense of condenser tubes, but this is often aggravated in large and important plants by the fact that the water and the body of the condenser have formed a convenient path for stray electric railway return currents getting back to their own power station some distance away, through the condenser intake and the salt or frackish water of the harbor.

A sufficient number of voltmeter readings were taken between the river, the flume and various parts of the piping about the building and in the streets to indicate that there was at all times difference of potential enough to make trouble, although its polarity was not always the same.

The metallic connections of the power station equipment to the city piping station are through two 14-in. connections to the water mains, and on account of the proximity of water mains to the trolley tracks all over the city, there is a tendency for stray currents to flow into the piping of the building and thence to the condenser intake, returning through the river to the negative bus bars of some neighboring street railway power plant. Currents flowing in this direction are certain to cause electrolytic corrosion in the condenser tubes with consequent short life.

The method adopted to prevent this corrosion consists first in providing a shunt circuit between the incoming water pipes and the condenser flume, in order to divert as large a proportion as possible of the current from the condensers. This was done by the insertion in each water main connection of a short piece of pipe with an insulating joint on each end of it. These short pieces of pipe were then connected to a 750,000 C. M. cable, which was carried to the outer end of the condenser intake. Such current as may leak from the pipes to the water contained in them thus has an opportunity to get back into the harbor without going through the piping system and the condensers.

In order to neutralize the effect of such current as might still leak past the insulating joints, a small booster generator was provided driven by a 220-volt motor, the positive pole of the booster being connected to the heavy grounded shunt cable above mentioned, the negative pole being connected to seven different points on each condenser, there being an adjustable rheostat in each of these branches of the negative circuit. This superimposed voltage can be adjusted by means of the rheostats to exactly counterbalance the natural galvanic electromotive forces due to the brass tubes, the iron shell and the circulating water, together with the stray electromotive forces from outside. With the destructive potentials so counterbalanced, the condenser is in a neutral electric state, which effectively prevents the corrosion and pitting of condenser tubes and sheets and secures a far longer life than has hitherto been possible for this very important and highly vulnerable section of the steam equipment. A little switchboard panel is provided for each condenser, with seven rheostats mounted on it, each of which is connected by a separate negative lead to a different section of each of the three condensers.

A differential voltmeter is provided which can be plugged to each of these sections of the negative circuit, there being a separate rheostat in each circuit. By adjusting the rheostats for each section it is possible to keep the potential at zero in all of them. The booster apparatus shown in Fig. 3243 is conveniently situated in the electrical bus gallery directly under the operating gallery. The rheostat panel for each condenser is situated conveniently to it in the engine room basement, and observations at suitable intervals enable the operating force to maintain the condensers absolutely neutral.

ORGANIZATION FOR THE WORK.—Two companies have been incorporated through which the Pennsylvania R. R. Co. is carrying on its New York extension work. One of these, the Pennsylvania, New Jersey & New York R. R. Co. will build all of that portion of the tunnel and approaches in the State of New Jersey and extending under the Hudson River to the boundary line of the States of New Jersey and New York; from this boundary, the other, the Pennsylvania, New York & Long Island R. R. Co., will construct the tunnels, terminal station and yards on Manhattan Island, under the East River and in Long Island City. The officers of these companies are the officers of the Pennsylvania Railroad Co., the president being Mr. A. J. Cassatt.

The engineering and architectural features are sub-divided in accordance with the character of the work, the whole project being under the general direction of the management of the Pennsylvania Railroad Co. The tunnel work proper is divided into two parts; the East River division being under the direct charge of Mr. Alfred Noble, M. Am. Soc. C. E., Chief Engineer, and the North River division under the direct charge of Mr. Charles M. Jacobs, M. Inst. C. E., Chief Engineer; the general railroad facilities and the electrical and mechanical features of the railroad and terminal are under the charge of Mr. George Gibbs, M. Am. Soc. M. E., Chief Engineer of Electric Traction. These three officials, together with Brigadier General Charles W. Raymond, Chairman, constitute a Board of Engineers to whom the general engineering features of the whole plan are confided. In addition, advisory committees consisting of officers of the road have been appointed to pass upon and work out the special problems relating to the required railway facilities, and pass upon the adequacy of the operating features as developed by the labors of the various departmental bodies. Messrs. Westinghouse, Church, Kerr & Co. have been selected as engineers and contractors for the electrical and mechanical engineering, acting under the supervision of the Chief Engineer of Electric Traction.

THE UNDERGROUND WATER SUPPLY OF THE CITY OF LOS ANGELES, CAL.

By W. P. Hardesty,* C. E.

The rapid growth of Los Angeles and the necessity of providing large quantities of water for lawns and parks as well as for domestic use has thrown a heavy and ever-increasing burden on those responsible for the water supply of the city. Ever since water-works were built the Los Angeles River has been the only source of supply of the city, first by direct diversion from the surface and afterwards by tapping the saturated beds underlying the river valley. In the development of the underflow some unusual methods have been employed, as will be seen from the following notes, based on a recent visit to Los Angeles.

*U. S. Reclamation Service, Cody, Wyo.

The population of Los Angeles has increased from 11,183 in 1880 to 50,935 in 1890 and to 102,479 in 1905, and it is now estimated at 200,000. Small works owned by the city were leased to a private company for 30 years from 1868. During this period the company practically built new and extensive works, so that when the city wished to take back the works in 1898 the water rights, only, were all that it could claim. After litigation the city regained possession of the works in 1901, paying $2,000,000 therefor. Mr. William Mulholland, engineer and superintendent of the company at the time of the transfer, was retained in that capacity by the city water commissioners, and has now been connected with the work for nearly thirty years. Other employees of the company were also retained by the city. In 1904 the city bought the works of the West Los Angeles Water Co. for $337,500.

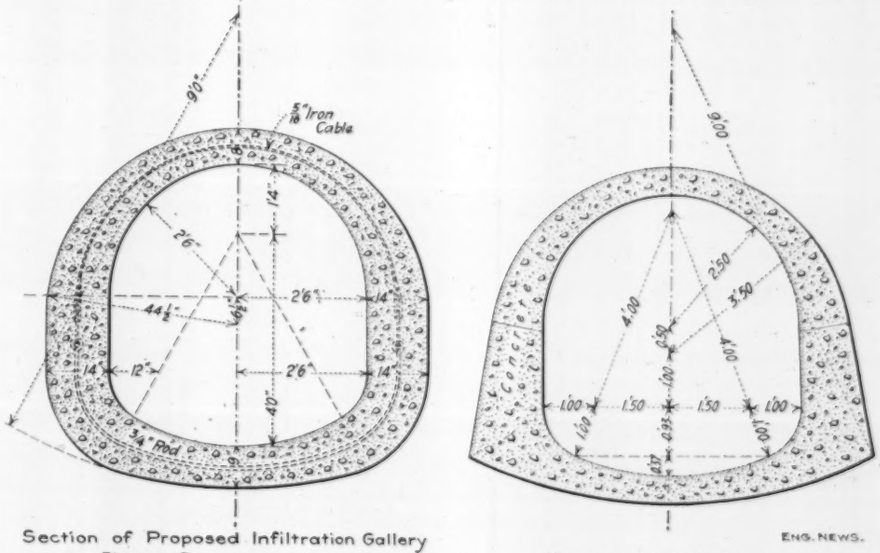
The city is supplied partly by gravity and partly by pumping, most of the water pumped going to reservoirs first. The main diversions from the river, chiefly from its underflow, are four in number, 8, 5 and 3 miles above the Narrows, respectively, and one at the Narrows.

The Los Angeles River is mainly fed by the precipitation on the southerly slope of the Sierra Madre mountains. Except during floods (following heavy storms) but little of this precipitation ever appears as surface flow in the river.

The river does not head in the mountains, but originates in the broad San Fernando valley. The latter is a basin about 10 by 20 miles in extent, into which drain the canyons of the adjoining mountains. The discharge from these is ordinarily absorbed by the deep beds of sand and gravel in the valley. Under conditions of ordinary rainfall, such as have preceded the series of dry years through which Southern California is now passing, water first appears in the river at a point about 11 miles west of the east end of the valley, at which latter point the river takes a large turn to the south, flowing through a narrow valley for about six miles, when it passes through a contraction in the valley, called the "Narrows," in the northeast part of Los Angeles. Beyond here is another valley, which widens out until it is lost in the broad plain adjoining the ocean.

At the Narrows the greatest depth through the debris of the river valley to bed-rock is only about 90 ft. The lowest point of the bed-rock here is at elevation 223 ft. above sea-level, while several miles up the valley borings to points below sea-level have not encountered solid rock, showing conclusively that, geologically, the valley is one of construction and not of erosion.

This condition is most favorable for the existence of the enormous underground reservoir which here exists, by reason of the great width and



Section of Proposed Infiltration Gallery under River, on Pomeroy and Hooker Land.

Section of Main Conduit.

FIG. 1. CROSS-SECTION OF INFILTRATION GALLERY AND OF MAIN SUPPLY CONDUIT, LOS ANGELES WATER-WORKS.

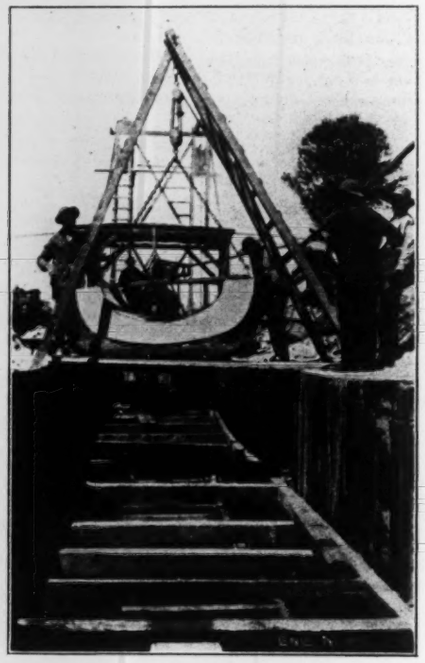


Fig. 2. Lowering Concrete Invert Block, Los Angeles Infiltration Gallery.

depth of the bodies of sand and gravel overlying the bed-rock.

The normal flow of the river gradually increases from where it first appears down to the Narrows and, although small, it would be sufficient for the domestic supply of the city if maintained at the rate that was usual until the cycle of comparatively dry years through which this vicinity has been passing. The rainfall is extremely variable, ranging from 38.13 ins. in 1883-4 (the year beginning July 1) to 5.58 ins. in 1898-9. The average annual is about 16 ins., based on a record for 26 years. Very often consecutive years exhibit an enormous variation.

The surface flow before spoken of does not fluctuate nearly so rapidly as the rainfall, as it is derived from underground water that gradually finds its way to the surface, due to the fall in the valley and the contraction towards its lower end. In view of the unreliableness of the yearly rainfall and the scanty run-off during the summer months from the mountains, it is fortunate for Los Angeles that the formation of the San Fernando valley is such that the underground reservoir exists, by means of which the excess precipitation of one season or a series of seasons is stored up, to be carried forward to the drier seasons. The "development" or utilization of the underground water has, of late years, been the chief means of increasing the city's water supply.

INFILTRATION PIPES.—Until recent additions to the plant were made practically the whole domestic supply to the city was conveyed through a 44-in. conduit, supplied from two double lines of infiltration pipes located some five miles above the Narrows. One of these lines run northwesterly up through the river bottom until it attains a depth of 12 ft. in its length of 1,650 ft. It consists of two lines of open-jointed vitrified pipe, reducing from 16 ins. diameter at the lower end to 12 ins. at the upper end. The other double line runs northerly through the gravel beds, passing along and under the river bed, until it attains a depth of about 14 ft. in a distance of 3,650 ft. The size reduces from 24 ins. at the gate chamber to 12 ins. at the terminus.

The pipes are bedded in coarse gravel and broken rock, to prevent the inflow of sand along with the water through the open joints. Trouble has always been experienced by roots penetrating the joints and tending to obstruct them.

About 6,000,000 gals. per day have been obtained from these four pipes. Water has also been taken in at the gate chamber by direct diversion from the river, so that altogether about 23,000,000 gals. have been fed into the conduit.

The conduit from these infiltration pipes to the city reservoirs consists of tunnel, masonry conduit, 19,152 ft. of 44-in. steel pipe, and some 48-in. steel siphons.

INFILTRATION GALLERY.—This is located eight miles above the Narrows, at Elev. 452 above sea-level, and the conduit leading from it closely follows the line of an old ditch once used to supply the more elevated portions of the city. In building the gallery, which extends beneath the river valley for a distance of 406 ft., a trench 20 ft. deep at the shore end was excavated, in which the concrete sections forming the gallery were built.

The construction was as follows: The completed gallery is a concrete conduit of the dimensions shown by Fig. 1. The conduit was built of block sections, not over 2 ft. long. The invert sections were formed outside of the trench. Each one was then lowered into the trench (Fig. 2) and bedded firmly, to grade and line, on the prepared gravel bottom. The sections were placed touching each other. On the invert was built in place the upper part of the conduit, which is continuous. The parts were connected as follows: In each lower section there was embedded, as built, a ¾-in. iron rod, running through the middle and with ends extended up through the horns of the section and each formed into a hook. In building on the top section two 5-16-in. iron cables were embedded in the middle of it. These were continuous, crossing alternately from side to side (following the curve of the arch) and looping through the hooks of the lower section, the arrangement being very similar to the lacing of a shoe.

By the method of construction adopted the lower portion could be placed without draining the trench of all its water. The abutting ends of the lower section allowed just enough space between them for the entry of water, without admitting sand and gravel.

From the gallery a tunnel 2,001 ft. long leads to a concrete conduit similar to the gallery in cross-section and in the general method of construction, except that the invert and sides are thinner and the sides continued down to connect with the invert, giving a broader [illegible] concrete conduit is 28,927 ft. long, and was completed in 1904 at a cost of $5.05 per [illegible] all the work of the water department built by day labor instead of by [illegible]

POLLOCK WELL AND PUMPING [illegible] STEM.—This plant is designed to tap all of the available underflow on the southwest side of the river at a point about three miles above the Narrows. In the valley, in a line [illegible] ding out from the river bank, are driven five [illegible] in. well pipes at intervals of about 150 ft. These have an average depth of 165 ft., and are perforated by rectangular slots all the way. A [illegible] in. suction pipe is run down each well a distance of 35 ft. The top is connected with the suction main by an elbow and tee.

The main increases in size from 7 [illegible] ins. at the first well to 15 ins. at the last one, beyond which is the pump. The latter has a straight lift of 39 ft. to the discharge into the 44-in. conduit, before described, and running on the hillside just above the flat bottoms. The pump main is 22 ins. in diameter and 1,500 ft. long.

In pumping, the water will be drawn down in the wells, so that a suction lift, never exceeding a practicable limit of probably about 26 ft., will be added to the 39-ft. direct lift.

The 12-in. centrifugal pump is run by a 125-HP. gas engine, at a normal speed of about 700 r. p. m. A small vacuum pump is used to prime the centrifugal pump when starting up. A very small exhaustion is required, as the pump is placed in a pit at about the level of the main.

It is expected that a supply of 1,000,000 to 1,250,000 gals. per day will be obtained from each of the wells. The plant was built in the winter of 1905-6.

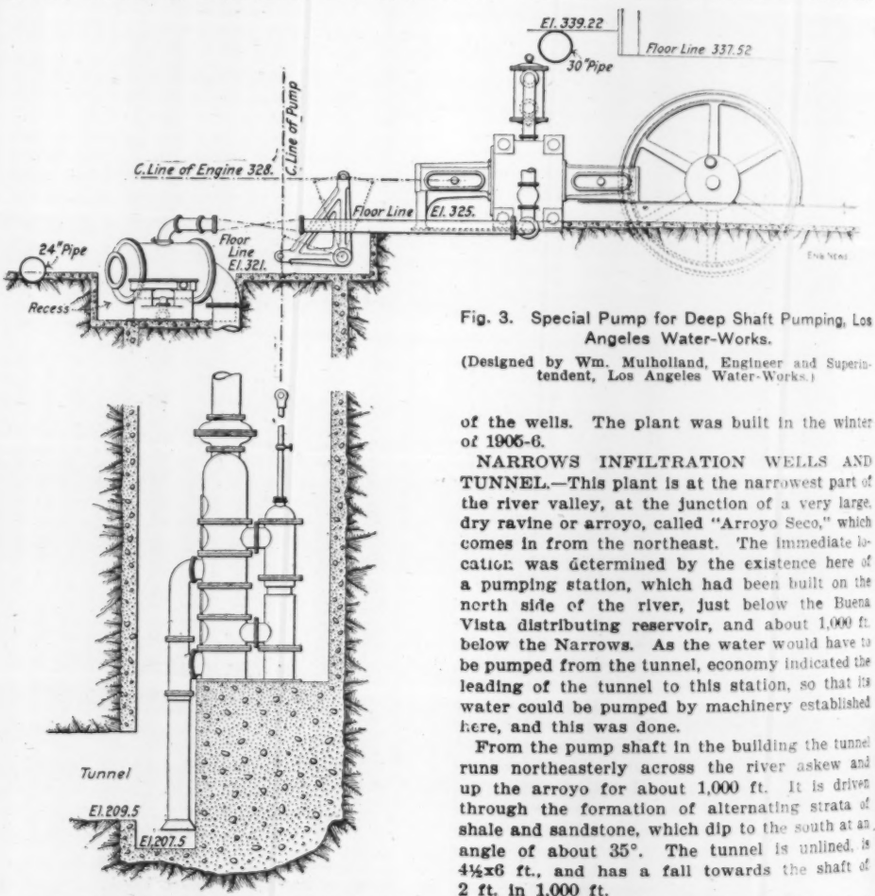


Fig. 3. Special Pump for Deep Shaft Pumping, Los Angeles Water-Works.

(Designed by Wm. Mulholland, Engineer and Superintendent, Los Angeles Water-Works.)

NARROWS INFILTRATION WELLS AND TUNNEL.—This plant is at the narrowest part of the river valley, at the junction of a very large, dry ravine or arroyo, called "Arroyo Seco," which comes in from the northeast. The immediate location was determined by the existence here of a pumping station, which had been built on the north side of the river, just below the Buena Vista distributing reservoir, and about 1,000 ft. below the Narrows. As the water would have to be pumped from the tunnel, economy indicated the leading of the tunnel to this station, so that its water could be pumped by machinery established here, and this was done.

From the pump shaft in the building the tunnel runs northeasterly across the river askew and up the arroyo for about 1,000 ft. It is driven through the formation of alternating strata of shale and sandstone, which dip to the south at an angle of about 35°. The tunnel is unlined, is 4½x6 ft., and has a fall towards the shaft of 2 ft. in 1,000 ft.

At the deepest part of the overlying bed of sand and gravel there is only 3 or 4 ft. of rock covering for the roof. Beginning at 554 ft. from the shaft there are nine wells sunk over the line of the tunnel, the last one at 2,167 ft. from the shaft. All of these except the fifth one are 12 ins. in diameter; the latter is 16 ins., and it is

placed at an angle point of 12° 30′ in the line of the tunnel.

The wells (of ordinary well casing) are perforated so that the underground water in the gravel and sand is taken in, dropping down through the wells into the tunnel. There is also considerable leakage through the bed-rock into the tunnel. The total yield of water to the tunnel is about 5,000,000 gals. per day. It is the intention to sink eight more wells, intermediate between the existing ones.

By use of this method of tapping the underflow the water through the entire depth of porous material is available, and it is, moreover, subject to considerable draft when far above the bed-rock. The proposition is the inverse of a submerged dam, as the draft creates a trough or depression in the saturation over the tunnel, with a tendency to quick drainage of the neighboring mass and an effect which must reach over hundreds of acres of land in the river valley and the broad Arroyo Seco. Though the latter is dry on top, there is a large underflow.

The expense of building the gallery as a tunnel in the solid rock is decidedly less than if located through the loose material overhead. The tunnel was driven from a heading at the pump shaft and also from headings at a shaft sunk at the location of the fifth well, which latter is 1,158 ft. distant.

BUENA VISTA PUMPING STATION.—At this station has been concentrated practically all the pumping that was formerly done at several small stations. The principal pumping done here is the raising of the water out of the Narrows tunnel or gallery (just described) and the lift of water from the Buena Vista Reservoir to a high service reservoir.

The pump shaft is in the building, at the lower end of the tunnel. The shaft is 14 ft. in diameter by 111.5 ft. deep, and is lined with concrete. At the bottom is the pump, of the deep well type. It is placed on a concrete foundation raised 10 ft. above the level of the bottom of the shaft. The draft tube reaches down into a small sump, next to the tunnel end. The pump is duplex, double-acting, with water cylinders 16¼x36 ins. The engine and pump (Fig. 3) were built by the Risdon Iron Works, of San Francisco, to a special design made by Mr. Mulholland. The pump is operated by a 3½-in. shaft reaching up to the engine on the floor of the building. This is a cross-compound pumping engine, with 20-in. high pressure cylinder and 40-in. low pressure. The engine and pump are connected through a bell crank at edge of the pump shaft. The arms of this are of unequal length, the "bob" arm being shorter than the engine arm, so that the engine stroke is 48 ins., while the pump stroke is 36 ins. The suction pipe is 18 ins. and the discharge 24 ins. The latter, just beyond its elbow at top of the shaft, passes through the engine's condenser, which is formed as an annular drum around it.

This pump lifts water from the bottom of the shaft (Elev. 209.5 ft. above sea level) 228.5 ft. to the surface of the "high gravity" reservoir, which is a comparatively short distance up the hillside. The rated capacity of the pump for this lift is 6,000,000 gals. per day. The pump was run for seven months after first installing in 1903 without stopping one minute.

In the same building is located a Snow steam pump of 7,000,000 gals. capacity. It pumps from the Buena Vista reservoir (Elev. 374) to a high service reservoir (Elev. 630). The former reservoir is located just back of the pump station and 50 or 60 ft. higher. The water is conveyed to the pump from this higher level, making the actual lift from the pump over 300 ft., but as the pressure in the feed pipe is carried to the back of the plunger in the water cylinder, the net head to pump against is simply the difference in level of the two reservoirs. This pump was installed in 1904, under the supervision of Mr. F. J. Fischer, the chief mechanical engineer of the water department.

WATER CONSUMPTION AND FUTURE SUPPLY.—In 1901, the year before the water-works were acquired by the city, the water consumption ran as high as 300 gals. per capita, based on a supply of 26,000,000 gals. to an estimated population of 85,000 supplied from the works. Since then, as the population has nearly doubled and the natural supply has not been increased, the per capita has been greatly reduced by the gradual adoption of meters for the larger consumers. It still runs as high as 200 gals. per capita during the warmest spells of weather in the summer time, but these last for only a few days at a time. The maximum recorded daily use is about 41,000,000 gals.

The extremely rapid growth of the city during the past few years, and the decreasing natural supply (as compared with preceding years), has necessitated increasing economy in use as well as a fuller utilization of the underground sources. In February, 1906, a court decree reaffirmed the sole right of the city to the underground waters stored in the San Fernando valley, before described, which had been encroached upon by the ranchers pumping it out for irrigation purposes. This additional pumping was fast depleting the gravel and sand of its stored water.

The increasing growth of the city has convinced the people of the need of taking radical steps to secure an entirely new source of supply, to provide for future years. For a year or so past there has been much discussion of a plan to bring water for the supply of the city of Los Angeles from the Owens River valley.

This valley is on the east side of the main Sierra Nevada range, near the east side of the State, but it is nearly north from Los Angeles. The total length of the water conduit has been estimated at 240 miles. During the winter of 1905-6 survey parties were engaged in making preliminary surveys for this project, and the results of this survey, when finally presented, will no doubt give some definite figures as to the probable cost. This has been variously estimated at from twenty million dollars to as much as forty million dollars.

THE MUNICIPAL ASPHALT REPAIR PLANT AT PITTSBURG, PA.

By Charles Brossmann, Jr.*

The municipal asphalt plant of Pittsburg, Pa., which was erected mainly for repair work, embodies some interesting features of asphalt plant construction and improvements which are of interest to municipalities doing their own repair work. The entire structure occupies a space only 40 × 46 ft. The building is of heavy timber framework, covered both sides and roof with corrugated iron.

The asphalt is melted and kept at the required temperature in two cylindrical steam-jacketed tanks, and from these it is conveyed to the mixer by gravity through pipes. The green sand is elevated from the ground to the mouth of a dryer by a continuous bucket elevator (at the extreme left, Fig. 1), is passed through the dryer, and after being heated to the desired temperature is discharged by gravity into the buckets of the bin elevator. This elevator is encased with steel in order to prevent loss of heat and the sifting of dust. The heated sand is conveyed by means of this continuous bucket elevator into the screen, which is placed above the sand bin. The material, after being screened, is dropped into the bin, where it is kept at an even temperature by means of steam-heated coils. Directly beneath the hopper is placed a mixer, the asphalt and sand being brought together at this point. After the materials are mixed to the proper proportions in the mixer the whole is discharged through a sliding door into the wagon below.

Power is obtained from an 8½ × 12-in. Leffel engine, running at a speed of 240 revs. per min. The engine room is directly under the melting tanks, or kettles. The boiler room is equipped with a 44-in. "Economic" boiler, operating at 100 lbs. pressure. The steam superheater is located in the boiler room, and is supplied by steam reduced

*Lemcke Bldg., Indianapolis, Ind.

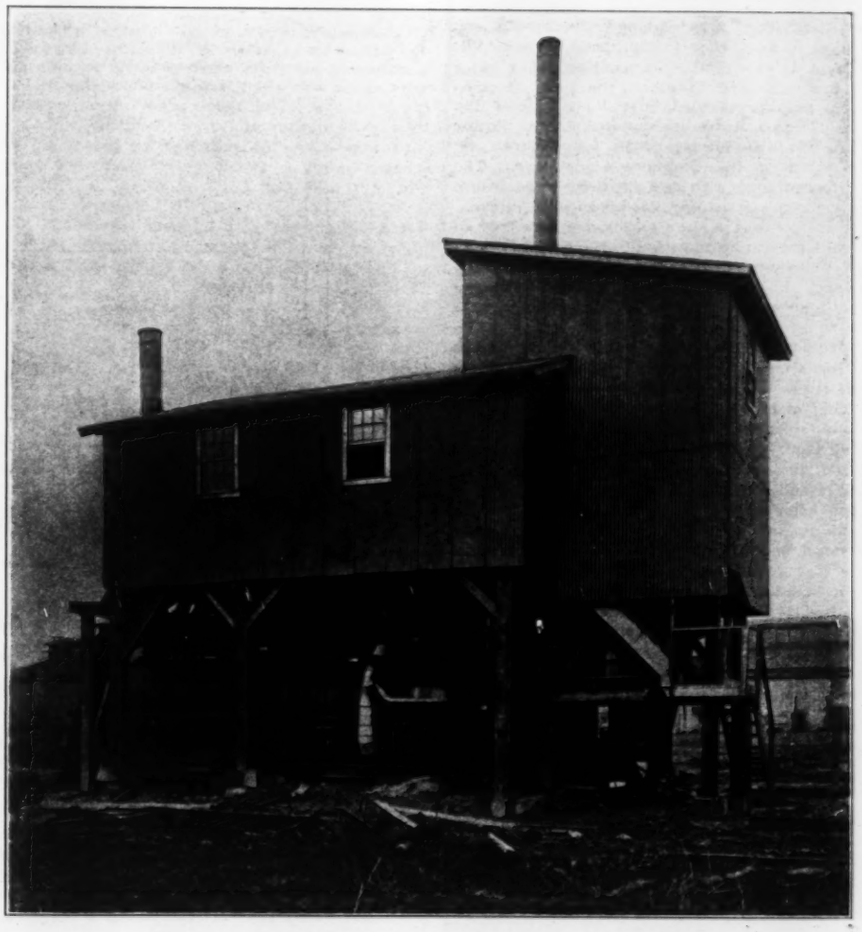


FIG. 1. MUNICIPAL ASPHALT REPAIR PLANT, PITTSBURG, PA.

to 10 lbs. pressure. The steam is then superheated and delivered to the melting tanks, or kettles, sand bins and to the asphalt cutting knife. Asphalt is elevated to the second floor by means of a barrel elevator placed outside the building, near the sand elevator. The contents of a barrel are first cut in two with a steam-heated knife especially designed for the work, then deposited in the asphalt melting tanks, or kettles.

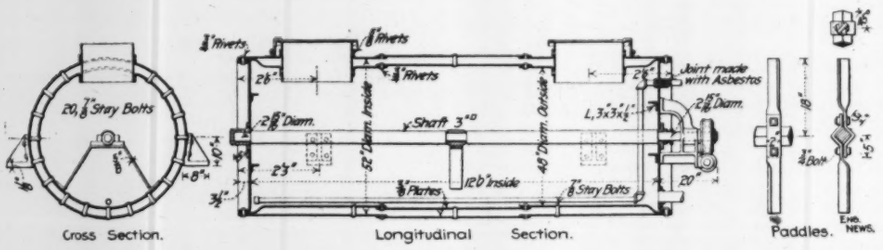


FIG. 2. DETAILS OF ASPHALT MELTING TANK FOR REPAIR WORKS, PITTSBURG, PA.

The two asphalt melting tanks (Fig. 2) are operated with low-pressure steam. They are steam-jacketed, 4 ft. in diameter and 12 ft. long, and have a total capacity of 7 tons. The asphalt is agitated both mechanically (see paddle details, Fig. 2) and with heated air. The air is supplied by an 8-in. Westinghouse pump, located in the boiler room. By forcing the heated air (Blake process) through the melted asphalt, the latter is dehydrogenized, and thus the use of oil or oil residuum flux is unnecessary. The resulting pavement has the qualities of lead under severe climatic conditions.

This method of using superheated steam for melting does away with all danger of altering the chemical constituents of the asphalt by charring or burning, which is likely to occur with direct-fired melting tanks, unless great care is exercised.

The sand dryer and heater is a conical rotary heater of the Blake type without obstruction or shafting through the center. The sand is agitated by baffling irons, placed longitudinally through the dryer and attached to the inside of shell. The fuel used is crude oil. Combustion takes place in a firebrick-lined chamber, the heat of combustion passing through and then around the dryer. Forced draft is supplied by a blower with a 10-in. discharge, which delivers into the draft tubes of the combustion chamber. The dryer is equipped with a King furnace to insure complete combustion and the absence of smoke.

The draft tubes in the fire-box are arranged so that cold air can be admitted in the desired quantity to temper the heat supplied to the sand dryer. The arch-shaped shell of the dryer is constructed of steel, lined in the dryer body with asbestos cement held in place by expanded metal. The fire-box is lined with firebrick. By means of by-pass flues, the sand can be kept at the required temperature, which is generally about 350° F. This method of heating the sand precludes the possibility of burning the asphalt by overheated sand.

The Blake mixer is arranged for preparing either standard asphalt mixture or else bituminous concrete. It has four buckets—two for screenings and two for melted material. The two small upper buckets discharge into a small mixer located above the main mixer. The two larger buckets discharge into the main mixer. In mixing bituminous macadam, the proper amount of screenings and asphalt are mixed thin in the small upper mixer, and in the larger mixer, directly below, is mixed the crushed stone and asphalt, making a fairly dry concrete. The contents of the upper mixer are then dumped into the lower one, where the two are mixed together and then dumped into the wagon below. In mixing standard asphalt, the small upper mixer and hoppers can be removed, the lower mixer being used alone.

A novel feature of the plant is the steam-heated knife (Fig. 3) for cutting asphalt before putting it into the kettles. This knife consists of a heavy hollow blade, with a steam connection at one end and a drip at the other end for the waters of condensation. This knife is a great labor-saver, especially when cutting such rubber-like materials as Texas asphaltic compounds.

The steam superheater (Fig. 4) is arranged to take steam at 10 lbs. pressure, which has a temperature of 240° F. It is therefore the duty of the superheater to make up this temperature to the required degree necessary for the different asphalts, generally in the neighborhood of 350° F.

The plant was built by the Kelly Springfield Road Roller Co. In connection with it there were furnished two 2-ton steam road rollers, a fire wagon, 12 standard tamping irons, and the necessary smoothing irons and rakes. The appropriation for the entire equipment and construction was $15,000. The capacity of the plant is guaranteed at least 500 sq. yds. minimum capacity per ten hours, but the plant could prepare material for laying double this quantity by the addition of another melting kettle. The plant was designed by Brossmann & King, Consulting Municipal Engineers, of Indianapolis, Ind.

ENGINEERS AND THEIR COMPENSATION.*

By Wm. D. Marks, C. E.†

Could we present the claims of our engineers upon their fellow men to an inhabitant of another planet unaware of the social organization that binds us, he would decree to them princely rewards for their beneficent labors.

Unfortunately, there is no such impartial tribunal, and instead of being princes of the earth engineers are usually very poorly-paid toilers, who are so much interested in the nature of things with which they deal that they have forgotten the ways of men, particularly those of the employing financiers who find their profit in promoting our great enterprises of which the engineer is the real brain power.

Without a mercenary thought, regardless of his own value, buried in the delight of his work, he toils for a meager salary, confiding the question of the future success of the enterprise to his employers. If it should not succeed he is usually forced to share the failure, although his engineering work may be perfect. If it succeeds his is the jackal's share share of the profit going to the promoter of prise. Very often impossibilities are asked of the whole burden of censure due to financial unjustly thrown upon him.

Engineering in its various branches has grown into an honored profession, and to engineers is awarded an abundant meed of public recognition. Why then is it that financial gineer is so inadequately rewarded for his services?

May it not be that engrossed in the study of nature he too often neglects to study the business? Will not his pecuniary rewards be addition to his scientific studies of them he tion of his thought to a financial investigation projects with which he may be connected?

We can divide business into two classes, legitimate and illegitimate. Whenever a man, for a fair profit furnishes his fellow men with the necessities of life he is doing a legitimate business. If cunning advantage of the weakness, the ignorance misfortunes or the vices of his fellow men more than a just profit or a fair wage from the is doing an illegitimate business.

To this latter class belong most of our very men, but not our engineers, for their's is a legitimate business, and for that reason it rarely in sudden and vast accumulations of money. engineer must earn his money honestly and slowly.

Consider the engineer as a commercial or business position. Until he is graduated from his college certainly is only an investment. And when at years of age he is thrown on his own resources with good luck, hope for forty years of earning Perhaps, however, thirty years is nearer his working life, and we will use this figure.

The investment in an educated engineer may be put down about as follows:

Living expenses to eighteen years of age	$12,000
College expenses, four years	5,000
Total	$17,000
Depreciation (for thirty years)	3% annually
Interest	3 "
Profit	5 "
Total	11% annually

If we assume this engineer to hold a salaried position his fixed expense is the cost of his living and his operating expense is nothing.

We then have as an adequate average salary for a technically-educated engineer:

11½% of $17,000	$2,000
Cost of living (for a single man)	1,200
	$3,200

Of course he will at first be obliged to begin on a very small salary, but he ought to hope to average $4,000 salary per year for thirty years, and earn $120,000 in his probable years of usefulness.

If an engineer opens an independent office and becomes a consulting engineer, his fixed and also operating expenses both exist, and his risk of loss and chance of profit

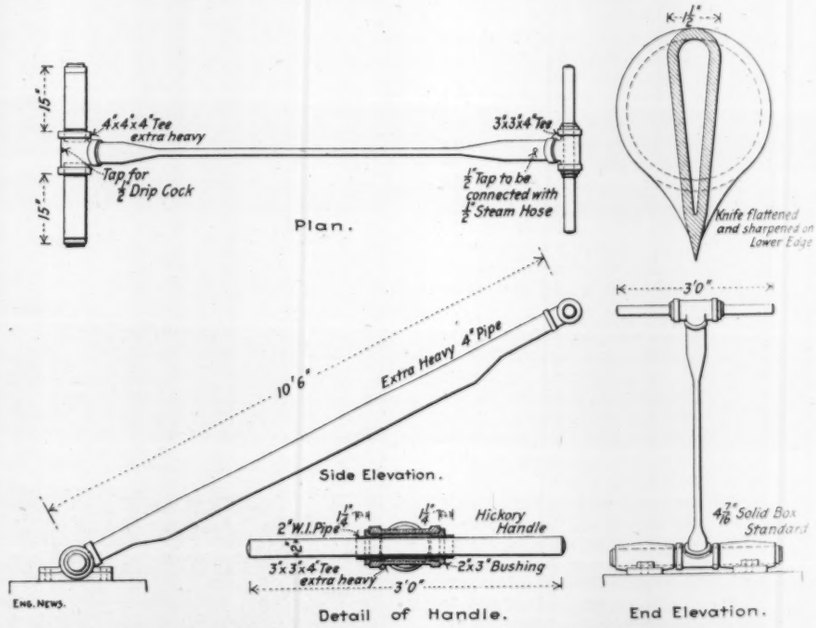


FIG. 3. DETAILS OF STEAM-HEATED ASPHALT KNIFE, PITTSBURG REPAIR PLANT.

*Extract from a paper in the "Journal of the Franklin Institute."

†218 The Bourse, Philadelphia.

both [illegible] However, if an engineer prefers to live upon [illegible]y and give only the occasional thought required by the commercial side of his various enterprises, [illegible],000 per year may be regarded as his probable average income for thirty years from purely scientific work.

In America a storm wind of prosperity has been driving all before it for years, and our ever-increasing schools of technology are pouring out civil engineers, mechanical engineers, hydraulic engineers, electrical engineers, marine engineers, sanitary engineers, mining engineers and chemical and gas engineers by the hundreds to join the rank and file of our industrial army as real captains of industry, trained to direct it in its honorable toil, but not to manipulate for personal profit.

These financiers, promoters, or exploiters of the public needs, own and control our steam and electric railways, our electric light stations and gas works, our fleets of steamships and our great hydro-electric power stations, and hire and pay our engineers to build and operate them. Those of our engineers not having the genius to force a well-earned fortune from nature by a profound and practical study of its laws, must, if they aspire to more than our average modest stipend of $4,000, study the laws of business and the methods and mental processes of our financiers, so frequently miscalled "captains of industry," for in truth the great majority of them are merely parasites upon the industries which they control, knowing nothing of their practical operations and relying upon engineers to do the producing.

A UNIVERSAL DICTIONARY OF MECHANICAL DRAWING.*

By George H. Follows.†

Part VII.—Dimensioning.

89. In attempting to lay down the general principles upon which a study of mechanical drawing should depend, I said, in Part I., that mechanical drawing is a language.

90. Now, the writing of a language may be for a variety of purposes. The English language, for example, is used in an almost endless variety of ways, to obtain an almost endless variety of results; from the speaking of a simple sentence, resulting in the making known to another person of a simple fact to the written expression of a scientific theory, based upon a multitude of facts, and resulting in the printed reference book for the benefit of many people.

91. For the guidance of those who use our language, comprehensive dictionaries and encyclopedias have been compiled, and a recognized science called grammar deduced; so that no matter what the result of writing the language may be, whether it be a reference book or a magazine story, an engineering specification or an advertising pamphlet, a railroad ticket or a theater pos-

(*Continued from Vol. LIV., p. 257; Sept. 7, 1905.)
†The Park View, East Liberty, Pittsburg, Pa.

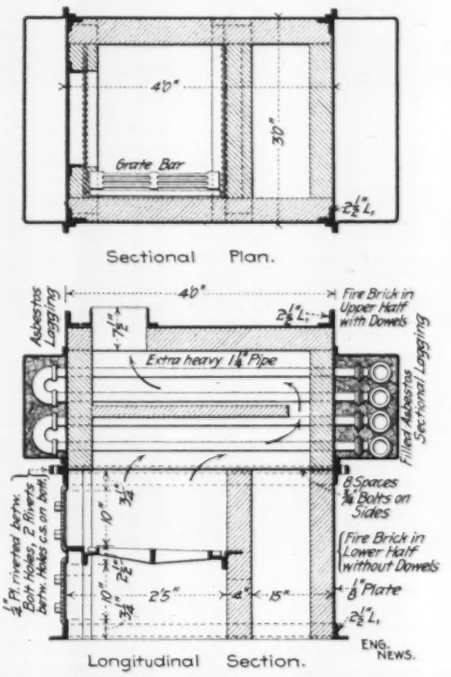


Fig. 4. Details of Superheater, Pittsburg Asphalt Repair Plant.

ter, the same alphabet and words are employed, with the same methods of sentence construction. But this similarity of language does not prevent us from easily distinguishing a railroad ticket from a theater poster, or a reference book from a magazine story; because each is built on its own lines for its own purposes. And it would be quite useless to try to formulate special rules for the preparation of one that would be of any practical assistance in the preparation of any other.

92. It is much the same with this language of lines, for there are many kinds of mechanical drawings; and before any attempt can be made to deal intelligently with the subject of dimensioning it will be necessary to arrive at a concise and comprehensive definition of the particular kind of mechanical drawing that this dictionary is intended to govern.

93. If the sole purpose of a drawing be to discover some unknown dimension, it is generally called a "layout." With the discovery of the dimension such a drawing has played its part; its work is finished. Similarly, if its purpose be to determine the contour of a cam, it serves its purpose and may be destroyed. Again a mechanical drawing may be in the nature of a thesis—an essay in lines, as it were; or it may be intended solely for descriptive or illustrative purposes.

94. So far as the language itself is concerned certain grammatical rules, as those governing projection and the meaning of the dimension line, must always hold; but there are many rules, among which are those that govern dimensioning, whose application will depend to a large extent upon the kind of drawing required and the uses to which it will be put.

95. *When a mechanical drawing illustrates the shape and construction of something that is to be made, and specifies the required product,—as by giving dimensions, material, finish and quantity required—it is in effect an illustrated specification.* This is the particular kind of drawing that we are interested in here and that this dictionary is intended to govern—the "illustrated specification," for the use of shop, office and drafting room, to be referred to again and again by those concerned in the manufacture, sale or design of the specified product.

96. In relation to such a drawing, the definition given in Part I.—that "mechanical drawing is a language of lines, views, dimensions, signs and abbreviations, notes and explanatory matter, all for the positive conveying of exact information"—has an interesting significance, for we may at once divide the drawing into three simple elements—illustration, dimensions, and written matter.

97. In composing such a drawing, the problem is how to distribute these elements so that each may play its part to the best advantage.

98. Taking first the illustration—the projected view or views—the primary purpose is, of course, to show a required shape or design; but this is not always the most valuable purpose *finally*. In every drawing the illustration is made to serve as a "vehicle" for the dimensions, and very often it is eventually of more value in this capacity than as a "shape." Take, for example, the illustration of the cast-iron armature spider in Fig. 19. After the pattern has been made, the drawing is referred to in the shop, not to discover the shape of the casting, because the pattern has fixed that and the casting is *there*, but for the dimensions and written matter.

99. It behooves the draftsman occasionally to remind himself of the fact that the man in the shop has the drawing in one hand and the piece

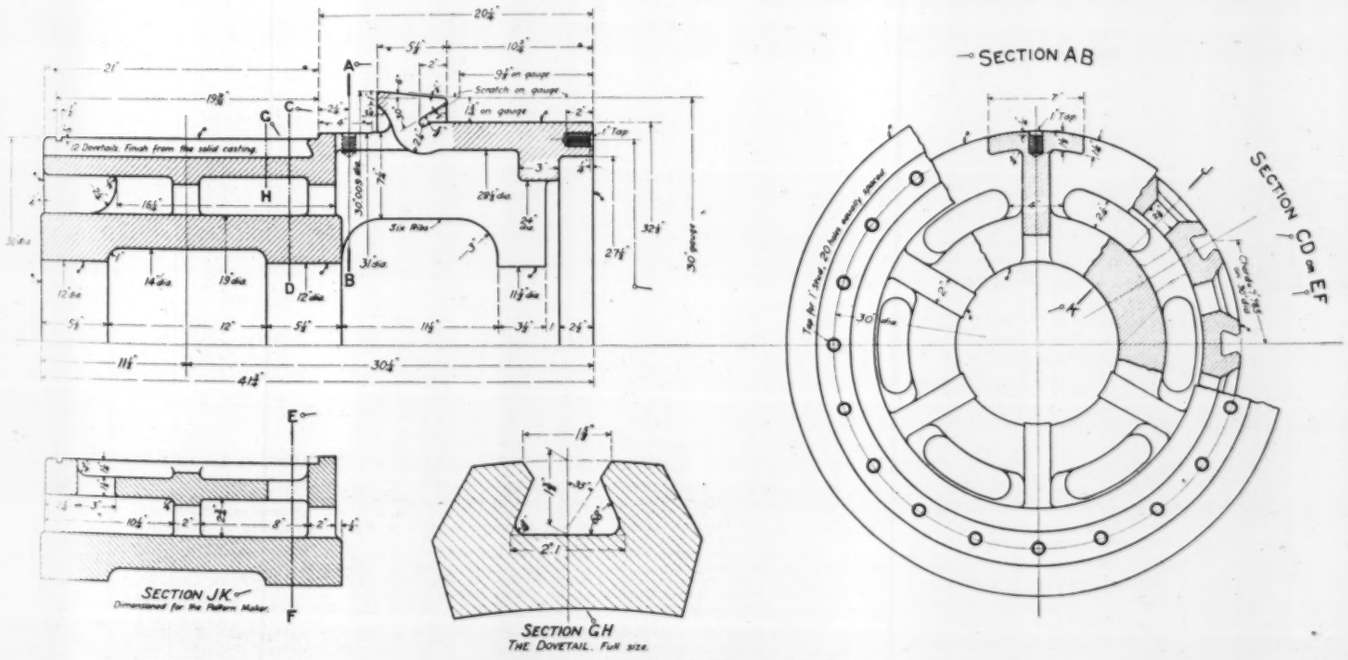


FIG. 19. CAST-IRON ARMATURE SPIDER.

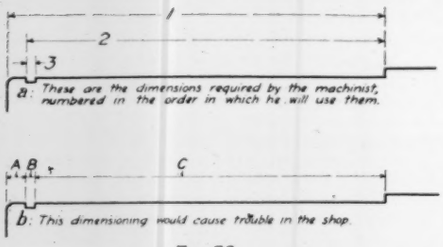

1
2
3
a. These are the dimensions required by the machinist, numbered in the order in which he will use them.
A B
C
b. This dimensioning would cause trouble in the shop.

Fig. 20.

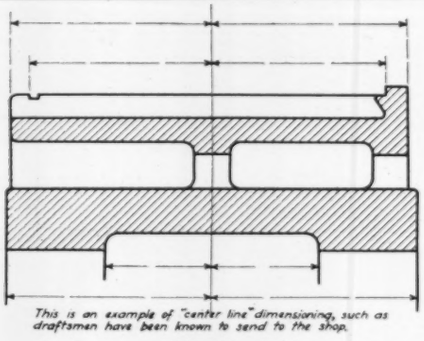


Fig. 21.

FIGS. 20 AND 21. EXAMPLES OF METHODS OF DIMENSIONING.
(Both are based on a part of the casting shown in Fig. 19.)

in the other, and is looking to the drawing for a dimension that he *needs* and has a right to *expect*; that if it is not given he has a right to complain, and that the illustration—as a "vehicle"—should carry the dimension *naturally*, where it can be easily found and easily read, and, if possible, where the man in the shop will naturally look for it.

100. *Dimensioning may therefore be defined as the art of determining what dimensions are required, and of applying them correctly to the lines and views of a drawing.*

101. REQUIRED DIMENSIONS. — It often happens that the dimensions used by the draftsman as he develops a design would not be convenient as working dimensions for the shop. In other words, the dimensions required by the shop are not always the same as those used in the drafting room. The shop requirements generally depend upon the way in which the work will be done—the manner in which measurements will be made and the order in which surfaces will be finished. Fig. 20 shows two dimensionings of a part of the casting illustrated in Fig. 19; at (a) the dimensions are numbered in the order in which the surfaces will be finished. Dimensioned as at (b), the shop would have to add A, B and C together to get No 1, B and C to get No. 2, and would not need A at all.

102. This leads to a statement of the first principle to be observed—*dimensions should be so given that the shop will not have to add or subtract in order to discover required distances.* This is only another way of saying "give the dimensions that the shop requires," except that it points clearly to the necessity of not being satisfied unless the dimensions are *individually* what the shop will want to *use*. Such dimensioning calls for a greater knowledge of shop methods than the average draftsman of to-day possesses; also for more thought than he usually gives to the subject; but it would go a long way towards removing that prejudice between drafting room and shop which we have come to look upon as almost a necessary evil.

103. So far we have spoken of the "shop" as though it were a unit; in reality the engineering shop consists of several more or less independent workshops, as pattern shop, foundry, machine shop, etc. Now, it is often necessary to bear in mind that the dimensions required by the different workshops may differ widely from one another, both in character and value. Thus, when the drawing represents a casting, as does Fig. 19, some of the dimensions will be especially for the pattern shop, others for the machine shop, some for both. It is always worth while to consider the shop requirements and the nature of the work to be done.

104. As a rule, the working or finish dimensions—those required by the machine shop—have the greatest value, and will rank first in importance, because they directly guide and control work done on raw material and have to play an active part during the entire life of the drawing (see Paragraph 35, Part III.). The dimensions for the pattern shop are generally of least "final value," not because they are any less important *originally*, but because, after the pattern has once been made, they are seldom used. In some drafting rooms special drawings are made for the pattern maker, carrying his dimensions only, the "working" drawings being thus relieved of their burden.

105. In Fig. 21 is an example of "center line dimensioning," such as draftsmen have been known to send to the shop. While these dimensions are often of value to the draftsman when laying out a design, and may be useful also to the pattern maker, they are seldom of much value to the machine shop, especially if the center line happens to be entirely "atmospheric."

Fig. 22 exhibits a good dimensioning of a flange coupling. Fig. 23 is in the nature of a "key" to this dimensioning, with explanatory notes.

106. Before passing to a consideration of the application of dimensions, the reader's a... is directed to the three Signs of Direction... Fig. 24. The "pointer" there shown deserves ...rd or two. Its purposes are stated, and it... several applications are illustrated. T... feature of it is the single-barb head, by ... is easily distinguished from the end of ... sion line. The single barb also enha... efficiency as a clear and definite point... uses should not be confused with those ... Indicator or the Arrow.

107. THE APPLICATION OF DIMEN... —In Part III. six "dimension construction... given. For convenience, they are repea... here in Fig. 26. The purpose of these constru... is to make it impossible for a dimension to ... misunderstood. Fig. 25 shows them applied t... circles and circular arcs—diameters and radii. ... the work of the average draftsman it is no... at all uncommon to find the radius of a round... corner given as at (a) Fig. 27. The arrangeme... shown at (b) is much simpler—so simple, ind... that draftsmen have been known to object, ... the ground that it is in some way ambiguo... yet there can hardly be any doubt as to its m...ning; it is, in fact, a perfectly rational way of in...icating such a radius. It is seldom necessary actually to mark the center of a rounded corner or fillet, because the position of the center itself is of no practical value to anyone; what the drawing should give is the nature of the curve, and this is done completely by specifying the radius length. In (a) the draftsman has used a pointer of absurd shape; that is what it really amounts to.

108. Fig. 28 shows how dimensions may be ap...

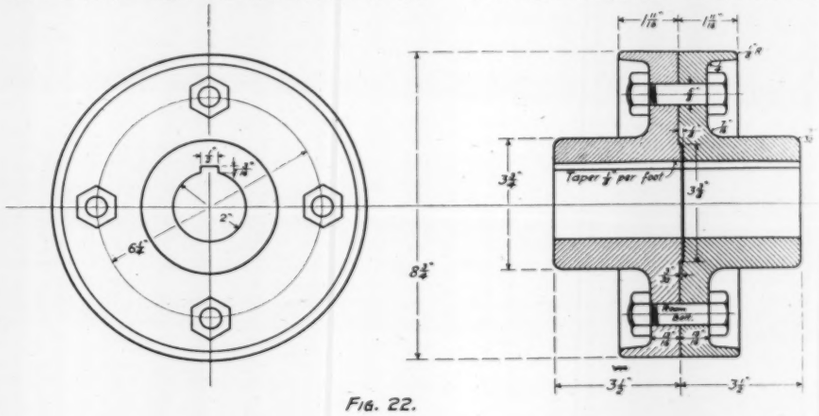


Fig. 22.

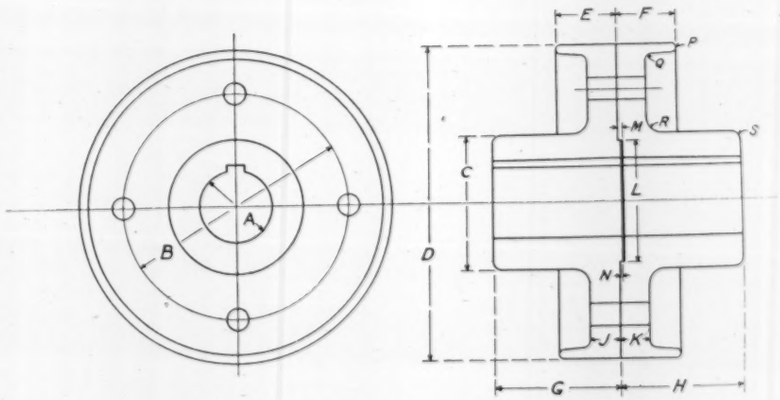


Fig. 23.

FIGS. 22 AND 23. GOOD DIMENSIONING FOR FLANGE COUPLING, WITH KEY TO SAME.

Key to the Dimensioning in Fig. 22 (see Fig. 23).

The following is intended to show that there is often a reason why a dimension should be applied in one place rather than another. The reasons are given, not because there is anything final or definite about them, but to suggest a line of thought, and to show that there is such a thing as intelligent dimensioning.

A: The bore will be measured from the end.

B: This center line circle will be laid out on the end.

C and D: The dimensions are applied as the diameters will be callipered.

E, F, G and H: These external dimensions are placed outside the view.

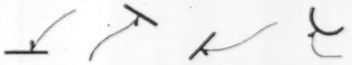
J and K: These internal dimensions are placed inside the view.

L: This diameter is placed as it will be callipered, and to the right because the part referred to points in that direction.

M and N: Each of these dimensions is placed on the half of the coupling to which it belongs.

P, Q, R and S: Grouping the radius dimensions in this manner is better than scattering them, and there is clear room for them on this side of the view.

UNIVERSAL DRAWING DICTIONARY.

THE POINTER:  Consisting of thin pointer line of suitable shape, with a single-barb head. The barb should always be placed on the more open side of the pointer line, thus ↙ never ↙. In general the Pointer is for definitely connecting a note or dimension with some part of the drawing. The barb should always touch the part referred to.

THE INDICATOR: Consisting of a short, medium-weight direction line with a small circle at one end. This sign is shown to advantage in Fig. 19 where it serves as an indicator between the sectional views and their respective cutting lines. The "indicator" also forms a part of the "substitute for a repeat dimension"; see Fig. 31.

THE ARROW: Consisting of thin direction line, shaded feather, and a double-barb head.
In general the arrow is for indicating direction of motion or force.

FIG. 24. SIGNS OF DIRECTION.

DIAMETERS and RADII: The following example dimensionings of diameters and radii are intended to show that no matter what the surroundings of a circle or arc may be, it is generally possible so to apply the dimension that the drawing will be easy to read and good to look at. In example A it is made clear that the $72\frac{3}{8}$" is a diameter, and in B that the $13\frac{1}{2}$" is a radius. The abbreviations "dia." for diameter, and "R" for radius should be used in this way whenever there could otherwise be a doubt as to the meaning of a dimension; but when the meaning is evident the dimension alone is sufficient.

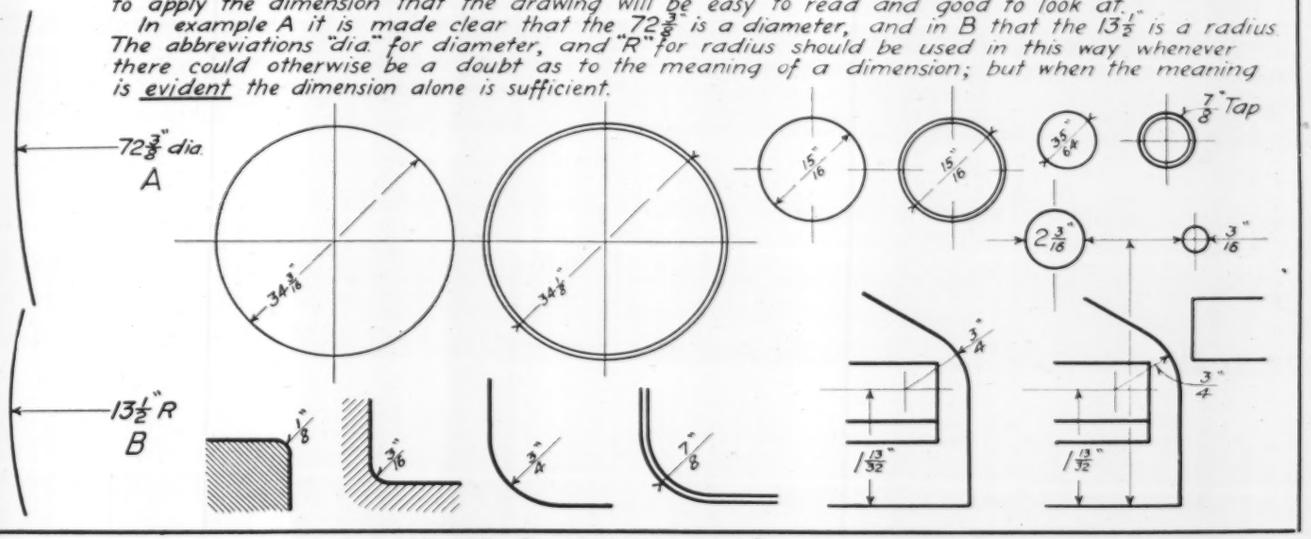


FIG. 25. THE APPLICATION OF DIMENSIONS

plied to a drawing of a shaft. The view has been made to serve efficiently as a vehicle for the required dimensions; it is best to put the bulk of the dimensions *above* the view, because when the shaft is in the lathe it is only the upper half of it that is visible; and it is reasonable to put the bearing center distances *below* the view, because in the complete machine the bearings will be under the shaft. Fig. 29 is reproduced from a drawing made by a draftsman who did not know how to dimension this shaft; dimensions that are thus thoughtlessly applied are almost always difficult to find: which means that time is lost and somebody's patience tried whenever the

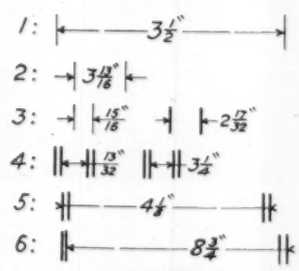


Fig. 26. Six Dimension Constructions.

drawing is referred to. It is not right that a machinist should be put to unnecessary trouble in order to read a drawing; he will do more and better work from a drawing that is easy to read than from one that has to be translated.

109. It will be noticed that in these drawings the dimension figure is occasionally placed as illustrated separately in Fig. 30. This is not a new arrangement. It is, however, so useful and so little used that something should be said about it. When the placing of the figure *across* the dimension line will make the drawing easier to read, it is best to place it so, because *drawings are made to be read.* It is true that generally the figure may lie *with* the dimension line, but when some other arrangement would be more readable it should be used; certainly *tradition* should not be allowed to stand in the way. In our every-day work we are all more or less slaves to tradition; a little flexibility is a good thing, and will often help the draftsman out of a tight place.

110. It would not be difficult to find grounds for advocating a more general use of the arrangement just referred to. In Fig. 22 *all* the dimensions are so arranged, and are certainly very easy to read. However, it would not be wise to altogether abandon the older method; it is probably better to use both, each where it seems right; though, after all, this is a matter rather of style than anything else, and does not affect any principle. Fig. 31 contains a suggested substitute for repeating a dimension. The greatest objection to repeating arises when a *change* is to be made; then, if by any chance a "repeat" is left unchanged, trouble may ensue. This special application of the Indicator is suggested, not because any general use of it is recommended, but in order that the draftsman may have such a device at his command: it sometimes helps.

111. It is impossible to lay down hard and fast rules for applying dimensions, because we are not dealing with an exact science, but the following may be taken as in a general way summing up the requirements:

(1) The illustration should be made to serve efficiently as a "vehicle," carrying the dimensions naturally; that is, with due regard to the manner in which the work will be handled in the shop, or the dimensions used elsewhere.

(2) Every dimension should be placed where there is clear room for it, and the construction chosen to suit the lines of the drawing and the space at disposal.

(3) Dimensions for one workshop should not be indiscriminately mixed with those for another.

(4) A dimension should not be repeated unless doing so will in some way make the drawing easier to understand.

112. Assuming sufficient knowledge and experience, a little intelligent thinking will enable the draftsman to meet these requirements; not in

Fig. 27. Wrong and Right Way of Indicating Radius of Rounded Corner.

every detail, and not in such a manner as to defy criticism, but certainly to an extent that will repay for the effort required. The dimensionings given of the spider, the shaft and the coupling were worked out with considerable care, and are *actual*, not imaginary, examples, being reproduced with very few changes from working drawings made some years ago. It is hoped that they will be of some assistance to the student of this interesting language, by showing him that by

simple means it is possible to make drawings that are in every way a pleasure to read.

113. Not many years ago the writer knew a young man who entered the employ of a large engineering concern as "tracer." He had previously been a salesman in a dry goods store, but was ambitious, and under the coaching of a friend had acquired some dexterity in the handling of drafting instruments, notably the tracing tools. He was naturally a good penman, and was soon able to make tracings that passed muster; and, being industrious, he finally became quite "expert," turning out neat work rapidly. By and by he was promoted to a position at the drawing board and was permitted to make detail drawings in pencil, and even to "dimension" them; in fact, was duly enrolled in the ranks as draftsman. In other words, this man, who had scarcely seen the inside of a machine shop, and actually did not know a lathe from a radial drill, was paid so much an hour for preparing "illustrated specifications" for the use of the shop.

114. In the face of this as a fact, is it surprising that there is some misunderstanding as to the real significance of the term draftsman, and some doubt as to his rank in the engineering professions? His cry for professional recognition is not without reason, but it can be of little or no avail until he is able, without supervision, to do his work as it should be done.

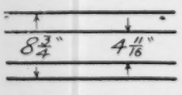


Fig. 30. An Occasionally Useful Way of Figuring a Dimension.

115. It is perhaps not too much to say that the successful draftsman of the future must be first of all an engineer, and then that his ambition must be not to get away from the board, but to develop his powers at the board, so that he may do better designing and make more efficient drawings of every kind. Of course, so long as the really efficient draftsman is as rare as he is to-day, he will continue to be called upon to assist the rank and file, and it will continue to be necessary, for economic reasons, to use him as a chief draftsman or foreman and to have working under him the draftsman of smaller caliber, whose duty it will continue to be to receive instructions, obey orders and work under constant supervision in all matters pertaining to the drawing as the writing of a language and as a "tool" for the use of the shop. And so long as our educational institutions separate mechanical drawing as a study from designing, the language from the writing and use of it, and graduate men who look with contempt upon the making of mere drawings, and consider any time they may have to spend at the board as an irksome preliminary to their advent as "engineers," so long will the graduate neglect to study drawing as it should be studied.

116. It seems as though the average draftsman of to-day is either not a student at all or is a student of something else than drafting: either unconsciously willing to go to seed as a "draftsman pure and simple" or ambitious to get away from the board altogether and be something other than draftsman, though just what that something might be he would often be puzzled to state. Far too many draftsmen are only theoretically ambitious, and neglect to see in their own work the direct road to success; it is their attitude towards their work that is at fault.

117. There is to-day a great field in the world of engineering for the really efficient draftsman: the one who loves his work at the board, who feels that drafting is a profession to be proud of, and who has made and continues to make a systematic study of the many branches of engineering that find expression in his work.

118. In the first place, he should be able without extraordinary effort to make an absolutely accurate layout; should be familiar with the principles of geometry and able to solve such mathematical problems as may present themselves. He should be well grounded in physics and broadly and intimately familiar with the elements of machine design; notably, perhaps, every kind of form of fastener, bearing, and means of transmitting motion and power; also of such mechanical contrivances as are most commonly used in machinery. He should be able to make a reasonably good free-hand sketch, and, not by any means of least importance, he should be able to make a vivid mental picture of what he draws and see in detail the results that will finally ensue in the shop. Outside of all this, he should have a clear conception of the business relations of the drawing with the shop and other departments. He must also keep abreast of the times in matters relating to shop practice, processes of manufacture and shop and office systems.

119. Nothing less than this will enable him to handle the language efficiently or to find lasting pleasure in his work. And possessing such knowledge, he will no longer have to spend his every working hour doubled up like a half-closed jackknife over the edge of a pine board, but will find extended to him a pleasurable and profitable variety of work.

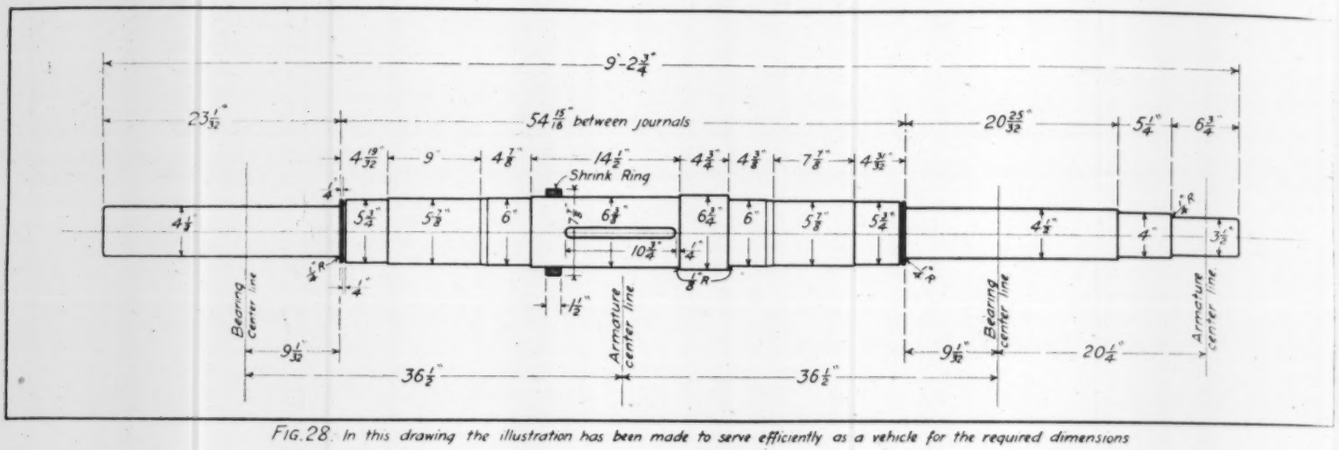


FIG. 28. In this drawing the illustration has been made to serve efficiently as a vehicle for the required dimensions

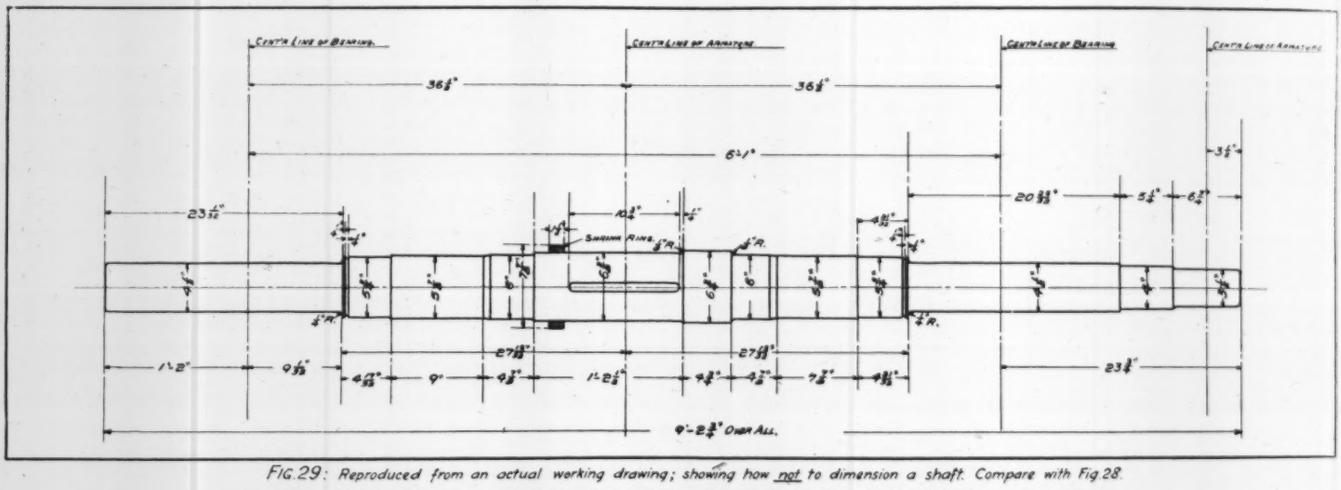


FIG. 29. Reproduced from an actual working drawing; showing how not to dimension a shaft. Compare with Fig 28.

FIGS. 28 AND 29. RIGHT AND WRONG METHOD OF DIMENSIONING A DRAWING OF A SHAFT.

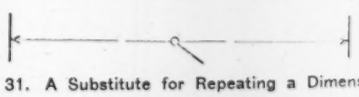
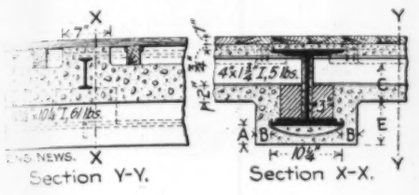


Fig. 31. A Substitute for Repeating a Dimension.

A NEW BUILDING FOR THE U. S. GEOLOGICAL Survey, at Washington, is provided for in a bill now before Congress. The estimated cost of a building with 150,000 sq. ft. of available floor space, exclusive of basement and halls, is $1,200,000. The Survey is now somewhat scattered in buildings and is paying $34,000 in rentals. Many employees are working in poorly lighted rooms and overcrowding is general. There is urgent need for a fireproof building to house the valuable records of the Survey.

THE COMPARATIVE RESISTANCE TO FIRE OF STONE CONCRETE AND CINDER CONCRETE.

Relating to the oft-arising question of the superiority of different classes of concrete as fire-resisting material, it may be of interest to note some of the results obtained by the British Fire Prevention Committee on floors of broad-flanged steel beams and concrete, reinforced by light steel joists. Tests were made on two classes of concrete, viz., ordinary gravel or Thames ballast concrete and clinker and coke breeze concrete. The construction of the floors in both tests were practically identical, the only difference being in the composition of the concrete. Both floors were



Details of Concrete Floor for Fire Tests.

For Thames Ballast.	For Clinker and Coke Breeze.
A = 2½"	A = 2¾"
B = 5"	B = 2¼"
C = 5"	C = 5¼"
E = 5⅜"	E = 6⅛"
F = 2⅝"	F = 2⅝"

designed to carry a load, including the weight of the floor, of 392 lbs. per sq. ft. The steel work consisted of rolled steel, broad flanged beams each 10½ × 10¼ ins., 4 × 17 ft., weighing 61 lbs. per linear foot, placed transversely across the hut. These beams divided the hut into three bays, 7 ft. between centers, which were subdivided longitudinally by small 4x1¾ ins. steel joists, weighing 5 lbs. per linear foot, placed 2 ft. 4 ins. between centers. These joists were not connected to the steel beams, but simply rested on bricks placed on the flanges of the beams. The ends of each steel beam were connected longitudinally to the adjoining beam by ¾-in. wrought iron rods, but this provision was considered unnecessary and of little advantage by the designers. Expanded metal, 1½ ins. mesh, ⅛ in. x 16 gage bare strands, was placed under the lower flange of each steel beam and turned up over the lower flange about 2¼ ins.

The Thames ballast concrete was composed of 2 parts washed sand, 4 parts unscreened washed gravel, and 1¼ parts Portland cement. In the floor of clinker and coke breeze concrete the concrete encasing the small steel joists and forming the body of the floor consisted of 3 parts furnace clinker broken to pass through a ¾-in. ring, 2 parts sand, and 1 part Portland cement, while the concrete casing to the four steel beams was composed of 5 parts coke breeze broken to pass through a ⅜-in. ring, and 1 part Portland cement. The Thames ballast concrete was allowed 70 days (summer) for drying, while the clinker and coke breeze concrete was allowed 65 days (winter). The accompanying cut shows wherein the dimensions of the laid concrete varied in the two tests.

The ceilings of the floors tested were 8 ft. 1 in. above the pavements of the chambers, the required loads on them being obtained by placing bricks on the wooden flooring, which was nailed to wooden strips placed in sinkings in top of the concrete. The fuel used was gas admitted through four 5 ft. x 3 in. mixing chambers of firebrick, and the temperatures were obtained by Roberts-Austin pyrometers placed at various points in the hub.

The results of the tests were as follows:

The floor of Thames ballast was heated for four hours, the highest temperature in the hut, at the end of that time, being 1680° F., the lowest 1600° F. Water was then applied 4 min. 20 sec. at about 65 lbs. pressure. In 22 minutes after the commencement of the test the soffit of the concrete floor began to split off in patches, and continued to do so at intervals during the test, while in 75 min. the whole concrete casing of the lower flange of one of the beams fell, a second one falling in 100 min. The steel beams began to deflect in 20 min. and continued to do so, the more rapidly after the concrete casing fell, until a maximum deflection of 7 3-10 ins. was recorded. In 215 min. the concrete between the joists of the north bay began to fall, and the wooden flooring became ignited, while the lower flanges of the beams, where the concrete casing had fallen, were heated red hot when the heat was shut off at the conclusion of the test. On applying the water more of the soffit fell, and eventually nearly all the concrete remaining between the cross joists of the north bay fell, the wooden floor becoming ignited.

Four days after the tests the following observations were made: The wooden floor was burned away between seven of the small joists and the concrete had fallen, while all of the remaining flooring was discolored on the underside, although showing no signs of fire on top. The permanent deflection of the steel beams was 4⅞ ins., none of the joists being dislodged, bent or twisted. The fallen concrete and the under surface of the concrete left in position was disintegrated.

The floor of clinker and coke breeze concrete was heated for four hours, the highest temperature in the hut on turning off the heat at the conclusion of the test being 1800° F., the lowest 1850° F. Water was applied by two ½-in. nozzles at about 60 lbs. pressure for 5 min. Small pieces of concrete began to split off the soffit in 25 min. after the commencement of the test, other small pieces falling in 31 and 45 min. In 50 min. the soffit of the concrete showed no change, but as the heat increased it gradually became incandescent and remained so until the end of the test. On applying the water some of the concrete on the edges of the beams was detached and the soffit of the floor was eroded. The maximum deflection of the floor was 0.35 in.

Three days after the test the following observations were made:

The top surface of all the floor boards was intact and showed no signs of fire, although some of the boards were discolored on the under side, and one of the strips, where it had laid across a crack, was charred, but neither fire or water had passed through the floor. Fine cracks had developed in the top surface of the concrete, but the general condition of the concrete on the under side of the floor was good, although the quality had deteriorated and was somewhat friable. There was no permanent deflection of the floor.

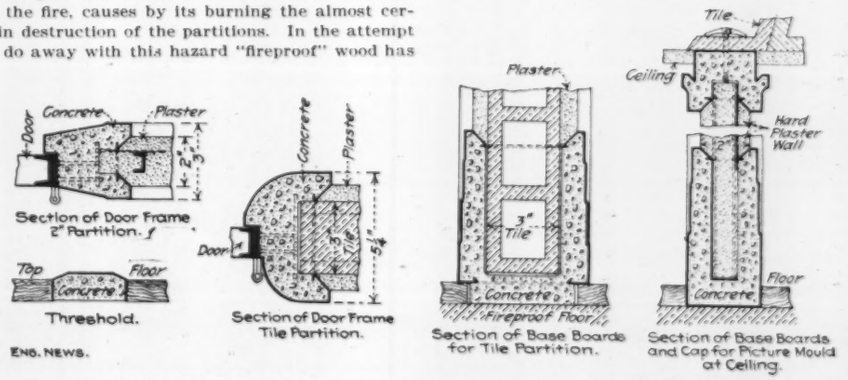
A comparison of these two tests clearly demonstrates the superiority of clinker and coke breeze concrete over Thames ballast concrete, and the unreliability of the latter as a fire-resisting material at high temperature. The tests also show that, when broad-flanged beams are used, the cross joists do not need to be connected to these beams if the concrete is carefully placed, but this construction exposes a wider flange to the fire which must be carefully protected.

SEPARATELY MOLDED CONCRETE TRIM AND FRAMES FOR PARTITION AND WALL OPENINGS.

A weak point in modern fire resisting construction of steel and tile is the use of wood trim and frames for baseboards and window and door openings. This woodwork, besides furnishing fuel to the fire, causes by its burning the almost certain destruction of the partitions. In the attempt to do away with this hazard "fireproof" wood has been resorted to. This is only a partial remedy. Another resort has been wood sheathed with sheet iron, and still another is the use of pressed metal frames and trim. The accompanying drawings show a third solution of the problem: it is the use of separately molded frames, baseboards and caps of concrete. This solution is proffered by Mr. W. D. Mann, a civil engineer of Chicago, Ill., and from information furnished by him we quote the following description of the construction and the advantages claimed for it:

The construction of this interior trim is entirely different from that of all others as it will be completed in the factory, even including the fitting of doors, the hardware and all finishing with exception of the last coat. It is then taken to the building and erected, thereby laying out all partitions for other mechanics and doing away with all wood frame work for openings and wood grounds for the plaster necessary for other trims. It can be used on all kinds of fireproof partitions. The walls are built after the trim is in place and when plastered the trim becomes a part of the wall itself, the wall being built in the socket of the fireproof frames, baseboards, etc., as shown by the drawings. If the wall is of tile, such tile is erected and then plastered after the trim is in position. Any other construction of wall can be similarly built. After the wall is erected and finished the trim is cleaned off, if need be, the chances being that more or less plaster will have been splashed or dropped upon it. The wall with its trim is thus completed and the plaster can harden and dry after such completion. It will be seen that this affords a very simple and cheap construction of wall and at the same time there is a great saving of time. Ordinarily the wall structure is erected and plastered and then the plaster allowed to harden before the trim is added. This waiting for the plaster to harden occupies considerable time which undesirably delays the construction and completion of the building and at the same time affords actual financial loss to the building owners by delaying the time when the premises can be occupied. There are no nails, screws or bolts used, with the exception of the stove bolts, that secure the door hinges to the frame. There are no cracks between the trim and the plaster to catch dirt, no swelling, shrinking or warping of doors, and no openings of joints. Alterations in partitions can be made with less trouble and expense and the trim will stand harder knocks and show less damage than wood trim. It can be finished in imitation of the different woods or can be made in the different metal finishes, thus doing away with paint and varnishes which are themselves combustible. The trim can be made in all the different shapes and styles. It has the advantage of being time saving, economical, substantial and absolutely fireproof.

THE DECAPOD TANK LOCOMOTIVE of the 0-10-0 type built a few years ago by the Great Eastern Ry., of England, as an experiment for heavy suburban service, has been converted into a freight engine of the 0-8-0 type. It originally had three cylinders, 18½ × 24 ins., but the middle cylinder and its connections have been removed. Owing to the enormous growth of the London suburban traffic the railway's facilities were overwhelmed, and Mr. James Holden, the Locomotive Superintendent, designed the decapod engine for hauling much larger and heavier trains than could be handled by the ordinary suburban engines. At the same time, it was recognized that the engine could not be put into regular service unless large sums of money were spent in strengthening the track and bridges, the weight being about 80 tons. The trials showed that the engine had ample power and acceleration, but the company concluded not to go to the expense of building new engines of this class and putting the road in condition to carry them. It is said that for the present the tank engines of the 2-6-2 type, with larger boilers and higher steam pressure, will be used to handle heavier trains. These have cylinders 16½ × 24 ins., and driving wheels 4 ft. diameter. The converted freight engine is to have a smaller boiler and fire-box, with 1,869 sq. ft. of heating surface instead of 3,010 sq. ft., and carrying 180 lbs. instead of 200 lbs. pressure; grate area 23 sq. ft. The engine as converted is designed to haul 50 coal cars of 20 tons capacity. Its wheels are 4 ft. 6 ins. diameter, with a wheelbase of 23 ft. 3 ins., and the outside cylinders drive the second axle.



SEPARATELY MOLDED CONCRETE TRIM AND FRAMES FOR PARTITIONS, DOORS AND WINDOWS.

A SIMPLE METHOD FOR THE CALCULATION OF THE BENDING STRENGTH OF CURVED PIECES.

By S. E. Slocum.*

In view of the recent discussion as to the distribution of stress in eye bars, a simple, general method for calculating the strength of curved pieces having any form of cross section whatever may be of general interest.

The best known formulas for the calculation of the bending strength of curved pieces are those due to Bach. For a piece of rectangular cross section these formulas are comparatively simple, but for any other form of cross section they become very complicated, involving long and tiresome computations. However, by a simple geometrical device, due to the French engineer, Jean Resal, these difficulties can all be obviated, and the bending strength of any curved piece obtained by a simple graphical calculation. The method is rigorous, and introduces such a marked simplification as to be worthy of general recognition. In order to explain Resal's method it will be necessary to give a brief development of the fundamental formulas for curved pieces.

The theory of straight beams is based on Hooke's law and Bernoulli's assumption that the cross section remains plane during flexure, from which it follows that the neutral axis passes through the center of gravity of the section. For a curved beam, however, the latter statement does not follow as a consequence of Hooke's law and Bernoulli's assumption; for since the fibers on the convex side of the beam are longer than those on the concave side, it will take less stress to deform them an equal amount. Consequently the neutral axis does not coincide with an axis through the center of gravity of the section, but lies nearer the concave side of the piece.

The first step, then, in determining the bending strength of a curved piece is to find the distance of the neutral axis below the gravity axis of the section. For this purpose consider a curved piece of any cross section whatever, and let l denote the length of any fiber and dl its change in length due to the strain (Fig. 1). Also

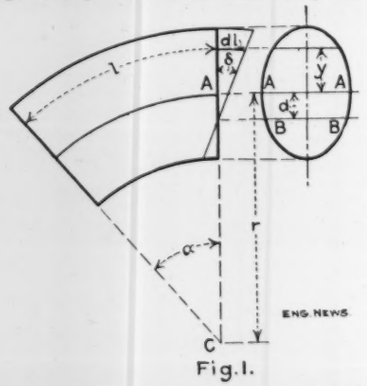


Fig. 1. Sketch of Element of Curved Beam.

let r denote the radius of curvature of the piece, α the angle between two plane sections, δ the angle of deformation of a plane section, A A the gravity axis of the section, B B its neutral axis and d the distance between the two. Then if y is the distance of the fiber l from the gravity axis A A, and α is expressed in circular measure, we have $l = (r + y)\,\alpha$. Similarly, $dl = (y + d)\,\delta$, where δ is also expressed in circular measure. From Hooke's law,

$$\frac{dl}{l} = \frac{p}{E}$$

where p denotes the intensity of the stress acting on the fiber l, and E is Young's modulus. Substituting in this expression the values of dl and l, and solving for p, we have

$$p = \frac{E\,(y + d)\,\delta}{(y + r)\,\alpha}$$

or, since E, δ and α are constants at a given section, this may be written

$$p = C\,\frac{y + d}{y + r}, \quad \text{where } C = \frac{E\,\delta}{\alpha}.$$

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Under the assumption of pure bending strain the shear is zero, and the normal stresses form a couple, that is to say, the algebraic sum of the tensile and compressive stresses acting on the section is zero. Therefore if dA denotes an element of area, and p the intensity of the stress acting on it, we have

$$\int p\,dA = C\int \frac{y + d}{y + r}\,dA = 0.$$

Dividing out the constant C, and separating the integral into two parts, we have

$$\int \frac{y\,dA}{y + r} + d\int \frac{dA}{y + r} = 0,$$

whence

$$d = -\frac{\int \frac{y\,dA}{y + r}}{\int \frac{dA}{y + r}}$$

which is the formula for the displacement of the neutral axis below the gravity axis.

Having determined the position of the neutral axis, the formula for the unit stress, p, can easily be obtained. Thus, equating the external bending moment M to the internal moment of resistance, we have

$$\int (y + d)\,p\,dA = M.$$

Substituting in this the value of p, it becomes

$$C\int \frac{(y + d)^2}{y + r}\,dA = M$$

whence

$$C = \frac{M}{\int \frac{(y + d)^2}{y + r}\,dA}$$

and, consequently,

$$p = \frac{M\,(y + d)}{(y + r)\int \frac{(y + d)^2}{y + r}\,dA}$$

For a rectangular cross section the integrals in these expressions for d and p can easily be evaluated. Thus let h denote the height of the rectangle and b its breadth. Then integrating between the limits h/2 and — h/2, the expression for d becomes

$$d = r - \frac{h}{\log_e \frac{2r + h}{2r - h}}$$

or changing to common logarithms,

$$d = r - \frac{.43429\,h}{\log_{10} \frac{2r + h}{2r - h}}$$

Similarly, the integral in the denominator of the formula for p reduces in this case to the single term b h d, and since the maximum stress is the value of p for

$$y = \frac{h}{2},$$

we have

$$p_{max.} = \frac{M\,(h + 2d)}{bhd\,(h + 2r)}$$

From this formula it is evident that the stress is greatest where r is least, that is to say, at the point of sharpest curvature.

For any section other than a rectangle, the integrals in the expressions for p and d do not lead to simple results such as those just given. Consequently, although the formulas are general, their application is only possible in certain cases in which the boundary of the section is a simple curve, such as a rectangle or circle, and then, in many cases, can be applied only with difficulty.

Resal's simplification consists essentially in a simple geometrical transformation of the boundary of the given cross section. To explain its nature, consider a symmetrical section (Fig. 2), and let M N denote the axis of symmetry, passing through the center of curvature, C, of the section. As before, let A A denote the gravity axis of the section, and suppose radii drawn from the center of curvature C to each point P of the boundary. From H, the point of intersection of C P with A A, erect a perpendicular to and from P draw a parallel P V to A A. the point of intersection P′ of these two will be a point on the transformed bou If, then, this process is carried out for a cient number of points P on the boundary original section and the new points P′ so are joined, a new boundary will be obtain shown by the broken line in Fig. 2. It can be easily shown that the gravity axis of transformed section coincides with the n

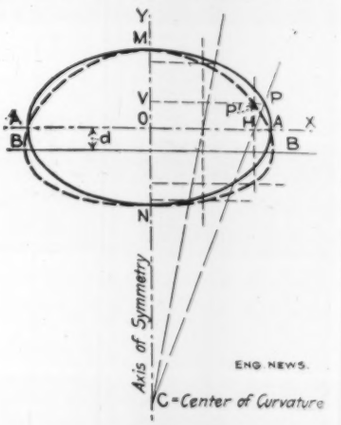

Fig. 2.

Fig. 2. Resal's Graphical Construction of Transformed Cross-Section of Curved Beam.

axis B B of the original section, and also that the moment of inertia of the transformed section about this axis is the integral which occurs in the formula for p.

In Fig. 2 let the gravity axis A A of the original section be taken for the axis of X, and the axis of symmetry for the axis of Y. Also let x, y denote the coordinates of P, and x′, y the coordinates of P′. Then

$$x' = VP' = OH = PV\,\frac{CO}{CV} = x\,\frac{r}{r + y}$$

The distance of the center of gravity of the transformed section below the gravity axis A A of the original section is

$$d' = -\frac{\int x'y\,dy}{\int x'\,dy} = -\frac{\int x\,y\,\frac{r}{r + y}\,dy}{\int x\,\frac{r}{r + y}\,dy}$$

Dividing out the constant r, and replacing the element of area x dy by dA, this expression becomes

$$d' = -\frac{\int \frac{y\,dA}{y + r}}{\int \frac{dA}{y + r}}$$

This value of d′, however, is identical with the value of d obtained in the first part of this article. Consequently *the gravity axis of the transformed section coincides with the neutral axis of the original section.*

Now let I′ denote the moment of inertia of the transformed section about its gravity axis B B. Then

$$I' = \int y'^2\,dA',$$

where dA′ denotes an element of area of the transformed section, and y′ denotes its distance from B B. Therefore, since

$$dA' = x'\,dy',\ y' = y + d,\ x' = x\,\frac{r}{r + y} \text{ and } dy' = dy$$

the expression for I′ becomes

$$I' = \int (y + d)^2 \left(x\,\frac{r}{r + y}\right) dy$$

or, since x dy is an element of area dA of the original section, and r is a constant,

$$I' = r\int \frac{(y + d)^2}{y + r}\,dA$$

This integral, however, is the one which occurs

in the formula for p, obtained in the first part of this article. Hence, replacing it by

$$\frac{I'}{r},$$

the formula for p becomes

$$p = \frac{M\,r}{I'} \cdot \frac{y+d}{y+r}.$$

This expression gives the value of p for a point at a distance y from A A. If the distance of the extreme fiber from A A is denoted by e, then the above formula becomes

$$p_{max.} = \frac{M\,r}{I'} \cdot \frac{e+d}{e+r}.$$

In applying this formula it is only necessary to determine the position of the gravity axis of the transformed section and calculate its moment of inertia about this axis. As both of these calculations can easily be made by the use of a planimeter in accordance with the graphical methods in common use, the simplification thus introduced is at once apparent.

SOME EXAMPLES OF CONCRETE MIXING AND DELIVERY PLANT.*

By Wm. G. Fargo.†

From the standpoint of the constructing engineer or contractor the writer will endeavor to describe several types of concrete plant suitable for moderately heavy work, and treating more especially the handling to and from the mixer, than the actual mixing process. There are many excellent mixers now on the market, even if the ideal machine of universal utility is still lacking. On many jobs of various sorts, 75% or more of the concrete is low down in the structure, so that it is easily possible to set the mixer and its bins high enough to avoid elevating much of the concrete after mixing. This is true of reservoir work, sewage and filtration plants, dams, and many buildings and bridges. It is obviously cheaper to handle the dry unmixed aggregates than the wet concrete, and therefore the mixer should be set above the bulk of the work, if it is economical to deliver the materials at that level. A rich grout will flow on a slope of about 3 horizontal to 1 vertical, on smooth planks; chutes for comparatively dry mixtures will require a slope of 40° or 45°.

For work of any magnitude, say over 1,000 cu. yds., it is usually cheapest, both in cost and time, to install considerable labor-saving plant for handling materials. Such plant comprises cableways, derricks, cars drawn by steam or electric locomotives, horses, or men, or hauled on inclines by cables and drums; elevators variously driven, and finally the wheelbarrow. With the present cost of labor and the frequent difficulty in securing efficient and hardy men, the wheelbarrow should be seldom seen on large concrete works. The steel tip car with roller bearings, running in oil in tight boxes, will enable one man to push, on level track, from five to eight times a wheelbarrow load of wet concrete.

In bringing materials to the mixer bins, wagons, cars or cableways are used. Wagons or cars drawn by teams may be used on grades of 2% as a maximum for teams, and about 4% or 5% for locomotives. Steeper grades will require cable haulage. A 5-yd. side-dump car with ordinary bearings weighing 2½ tons empty, and 12 tons loaded with gravel, is easily hauled on a 1½% grade by a single heavy team, and with some difficulty on 2% grades. With 5-yd. cars, use 20-lb. rails for team hauling, and 30-lb. or heavier for locomotive.

A cableway of say 800 ft. span, capable of handling a bucket for 1 yd. of concrete, will cost complete (with boiler, hoist and stationary towers 45 ft. high) from $4,500 to $5,000, and for movable towers about $1,000 more. When the delivery area must cover some width, transverse to the line of the cableway, more cableways are necessary, either parallel or transverse to the main cable. If the area is not too wide, derricks may economically re-handle the load. When the area of delivery is not too wide, and is located near one end of a cableway, one of the towers can be made to revolve about the other on a circular track. Traveling bridge coal and ore conveyors are made on this principle.

In 1903, on the harbor and dock improvements at Montreal, the writer saw an outfit well suited for building long walls of heavy construction. The plan, Fig. 1, needs little explanation. The ½-yd. tip cars, in trains of three or more, were hauled up a 1% grade by one horse, and the car body lifted off the trucks by the traveling A-frame derrick, dumped in the forms and replaced on the trucks; the horse in the meantime returning to the mixer, and the empty cars being dropped back singly on the switch track by gravity. This arrangement permitted about 400 ft. of work each side of mixer, or 800 ft. stretches of wall, to be built without moving the mixer. Had the dock line been straight, a cableway would have seemed preferable. It is usual to figure the strength of the main cable for a sag of 5% of the span, this requiring 45 ft. towers on an 800 ft. span, to deliver at the level of the base of towers, with 5 ft. clearance. Such a cableway might have a vertical speed of 150 or 175 ft. per minute, and a horizontal speed of say 700 ft. per minute, using 9 × 10-in. engines, and could make 20 round trips per hour for average haul on the 800 ft. cableway. Thus if 1-yd. buckets were used, 200 cu. yds. would be the maximum output for one cableway for ten hours. To increase this capacity would require more cableways.

For most building work or thin reinforced concrete work, a 1-yd. batch is rather large to dump into the forms handily, and ½-yd. batches are preferable on such work. On massive dams, or heavy foundations, the 1-yd. or 1½-yd. bucket is satisfactory. In certain work the large buckets of concrete are dumped on platforms or into movable charging hoppers over the forms.

On long retaining walls or dams, where the width of base is not too great, the cableway is especially valuable.

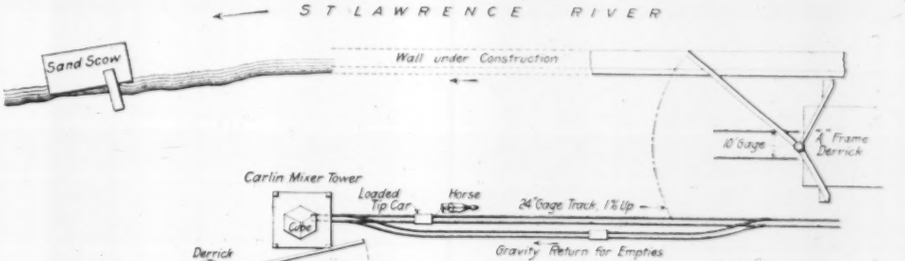

FIG. 1. PLAN OF CONCRETING PLANT ON MONTREAL DOCK WORK.

On works where the total width covered is a large fraction of the length, and other conditions are favorable, the trestle and car plant may be much cheaper than the cableway. When the distance from the mixers to the further boundary of the heavy work is less than 500 ft., there is no question of the cheapness and greater flexibility of track and small cars.

The minimum original cost of a single cableway was stated to be $4,500. Let us figure on a car plant for the same capacity of 200 yds. per day with length of 500 ft. out from the mixers. Assume the work to be 100 × 200 ft. in plan, with 75% of its bulk of concrete below the economical elevation of mixer, setting the mixer within 50 ft. of the near side of the work. If the work is under 3,000 yds. in bulk, and with reasonable time limit for completion, one mixer of say 200 cu. yds. per ten-hour day capacity will be suitable. Items of car plant cost are as follows:

Trestle, two tracks 24 ins. gage, 6 ft. c. to c.; 6 × 8-in. stringers, 22 or 24 ft. long ties, 2 × 6 ins., 2½ ft. c. to c.; 2 × 12-in. running boards between rails, 12-lb. rails. Trestle legs (50 ft. average length) of green poles at 5 cts. per ft., will cost complete about $1.50 per lin. ft. of double track, or for the 150 ft. at $1.50 erected, $225; five split switches with spring bridles, at $18, $90; two iron turntables, at $30, $60; three ⅔-yd. steel tip cars with roller bearings, $190; total, $565. (Spouts and hoppers are required on both types of plant, and are omitted here.) This outfit of cars and track material with 10% for repairs and renewals should be good for five seasons' work, and the timber work should be good for several jobs, if they are not too far apart. Adding 10% to first cost and dividing by five gives $124.30 as the yearly rental for this concrete delivery plant, or $1 per working day for a season of five months.

Three cars delivering ½-yd. batches will deliver 200 cu. yds. of concrete an average of 100 ft. from the mixer in ten hours. To run these cars five men are needed, including a man tending switches and turntable, and one man to help dump. At $1.75 per day for labor, the cost per cu. yd. is $8.75 divided by 200, or 4⅜ cts. per yd. Wheelbarrows on level planks will carry 2 to 2½ cu. ft., or say 12 barrows to the cu. yd., making the cost of transporting from mixer to forms 10½ cts. per cu. yd. Allowing 75 cts. per day for car plant and track rental, a trestle being required also for barrows, the saving in favor of car delivery is 5¼ cts. per cu. yd. However, it is not always practicable to load small barrows on large outputs of concrete, or on remote works to find and house the extra number of men needed to run the barrows. By using steel barrows or push carts on two large wheels, and holding 4 or 5 cu. ft., a 50 or 100-yd. concrete output per ten-hour day can be readily taken care of, and the extra switch and turntable items eliminated.

The accompanying cuts show some of the adaptations of car plant. Wooden spouts and hoppers lined with No. 20 black iron were used on the work illustrated. When the concrete is made wholly from finely broken stone or fine gravel, pipe spouts and metal hoppers are light and handy, but on the work under the supervision of the writer in 1905, for the heavy walls, the bank gravel was used unscreened and stones as large as a man's head went through the cube mixers and down the chutes into the work. Small round spouts and enclosed hoppers would be apt to choke with such material. On two dams on which the writer was engaged in 1905 it was possible to set the mixers on the ground at two-thirds the height of the concrete work. One of these jobs—the Muskegon River dam near Big Rapids, Mich.—contains 13,000 cu. yds. of concrete and is 55 ft. from the base to top. The concrete above the car track level (1,500 cu. yds.) was handled by means of a cage hoist on which the small tip cars were elevated to the top of the work, as shown in Fig. 2. A pile driver hoisting engine operated the cable. Fig. 3 shows the concreting plant, with the material cars

FIG. 2. BUILDING CONCRETE DAM AND POWER PLANT ON MUSKEGON RIVER AT BIG RAPIDS, MICH.
(Showing Elevator for Concrete Cars.)

*Abstract of a paper read at the annual meeting of the Michigan Engineering Society, and published in the "Proceedings" of the Society for 1906.

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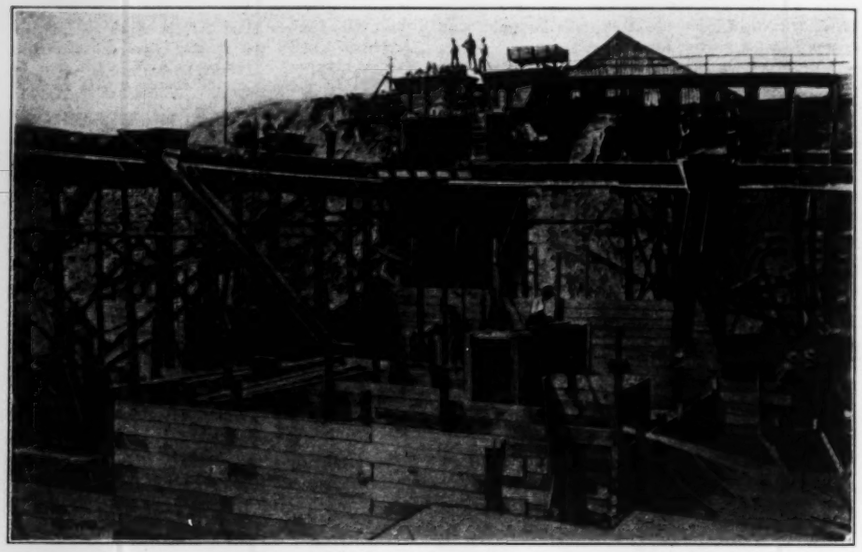

FIG. 3. CONCRETE-MAKING PLANT AT BIG RAPIDS DAM.

and bins, the mixers, the concrete cars and trestles and the dumping chutes. The movement is all by gravity from the material track to the forms, with the exception of the movements of the cars on the trestles. Fig. 4 shows the trestles and chutes at the power-house and penstocks; the tracks on the trestles are 40 ft. above base of foundations and have turntables at the corners. The 5-ton guyed derrick with 50-ft. mast and boom handles the structural steel and the timbers for the forms.

At the dam on the Kalamazoo River at Ceresco, Mich., with 15 ft. head and 25 ft. total height of concrete, the car track was within 8 ft. of the top of the work and as the upper portions of the walls were thin reinforced concrete, it was economical to use wheelbarrows carrying about 1 cu. ft. on steep inclines; also to shovel up to platforms. This dam and power-house contain 2,500 cu. yds. of concrete. There were derricks available on both these jobs, and a small amount of the upper concrete was handled by derrick in the stone skips.

The Ceresco dam was within about a mile of the Jackson & Battle Creek electric railway and a temporary line was tapped off the third rail and the 500-volt current used to drive the motors for the mixer and the pumps, including the 2-in. centrifugal water-service pump. Electric lights were used in the camp and for night work. This dam was built by the Commonwealth Power Co., which company furnishes the power to the electric road mentioned. Pile driving was started on this dam early in September, 1905, and concreting about Oct. 1. The concrete work on both the Ceresco and Big Rapids dams was in progress all through December. On this work, when the temperature dropped below 25° F., live steam was turned into the mixers or into the 15-barrel water supply tank, and the concrete went into the forms warm. In some parts of the work, not containing steel rods, salt was used in about one-third the quantity prescribed in Baker's "Masonry," or one ounce (instead of three) per gallon of water per degree below freezing. Some of the thin parts of the work were housed in with large canvas covers and kept warm with coke fires in very cold weather. None of the work has failed to set, and only a few places on corners or edges required any patching on account of freezing. Power dumping concrete mixers of the cube type were used on the above dams and were quite satisfactory.

In Michigan at present the bulk of all the concrete work is made from gravel, usually as it comes from the bank, containing enough smaller particles, grading down to sand, to leave the voids of the natural bank gravel at from 17 to 30%. In sand the voids run usually from 40 to 50%, so only enough sand is wanted to fill the voids of the fine gravel. In many gravel pits there is more or less stratification of coarse and fine material, and if no care is used at the pit to work the whole face and combine the different strata in each car or wagon load there will be larger percentages of voids.

Suppose the mixer charge contains the different sizes of gravel showing on the pit face. Then it is also necessary for a condition of minimum voids that the mixing machine be of a type capable of actually and surely scattering the fine particles among the coarse, in the minute or two that the charge is passing through. If the face of a stratified pit is raked and a mass of the rakings deposited on boards without further mixing, a test for voids (made on 25 or 50% of the mass) may show 25 or 30%, while a test on another 25% of the mass on the boards, after a few turns with shovels, will show perhaps only from 18 to 22% of voids. The reason is apparent. The fine material by proper mixing has been scattered so as to surround the coarse stones. Now if the mixing machine is of the conveyor type, it may not be capable of getting the best results from bank gravel, and yet may do exceedingly well with graded stone and sand fed from separate hoppers, simultaneously into the machine. Hence for mixing unscreened bank gravel, the machine should be of the tumbling box type and batch operation; or if plows or flights do the mixing, the material should preferably not be forwarded from the inlet to the outlet of the box or receptacle by the same means. In the selection of a mixer for use on various kinds of works, other things being equal, it is obviously important to select a machine of minimum height between inlet and outlet.

It is not often practicable to convey the wet, mixed product away by means of belt or bucket conveyors, but the raw materials may be readily handled in such ways. Inclined tracks for cable haulage of small cars work well for raw material delivery, but except with special cars would not answer for wet concrete. Concrete cars should be of simple construction, easily cleaned, dumping both sides or both ends as desired, and not having moving parts, bearings or latches in positions where they will become coated with concrete. Running a small charge of gravel with plenty of water through the mixer and cars whenever stopping work will keep them clean.

THE STARTING OF A 5,500-KW. STEAM TURBINE alternator under unusual circumstances is described in a statement furnished by its builders, the Allis-[illegible] Co., as follows:

The turbine referred to is installed in the Ke[illegible] power-house of the Brooklyn Rapid Transit Co. bine and its direct connected alternator were operation on Feb. 1, but the boilers, condensing tus, piping, etc., were not completed until late

While lying idle for nearly two months in a[illegible] pleted station, the insulation of the generator naturally became damp, and therefore, as soon was available for running the turbine, it was at part speed to dry out the generator.

This drying-out process was going on whe[illegible] morning of March 27 a mishap at another po[illegible] left the railway company short of power. The the situation was explained to the Allis-Chalm[illegible] sentatives at about ten o'clock, and they w[illegible] whether they could help out with the after[illegible] Feeling a strong confidence in their apparatus[illegible] Chalmers engineers decided to put the turbine[illegible] ular operation, notwithstanding the fact that it[illegible] been under load, nor had it even been up to s[illegible] when running unloaded at the West Allis sh[illegible]

Additional boilers were therefore fired up[illegible] hurried preparations made for starting. The t[illegible] tinued to run slowly until 12 o'clock to dr[illegible] generator. It was then shut down and the[illegible] proceeded with progressive tests of the insulatio[illegible] up to such a point as they considered safe for[illegible] voltage of 6,600, but not considering it wise t[illegible] high a test in view of the damp state of the[illegible]

The insulation tests were completed at 1.5[illegible] the turbine was again started up, and run up[illegible] speed of 750 r. p. m. for the first time since i[illegible] at the power-house. At 2.20 p. m. the engine[illegible] carefully assuring themselves that everything w[illegible] ing well, reported that they were ready, and[illegible] creasing load was immediately put on until at[illegible] turbine was carrying a little over 3,000 KW.

As more load was called for, it was put on, and[illegible] p. m. the unit was carrying over 4,000 KW. [illegible] following day the load ran up to over 5,000 KW. [illegible] the succeeding day it reached 7,000 KW., the tur[illegible] ing heavy loads during the morning and afternoo[illegible] and running until late each night.

On March 30 an opportunity was given to la[illegible] turbine and open it up for examination. Here[illegible] the operation of steam turbines, in numerous [illegible] turbine cylinders have slightly arched upward [illegible] the effect of superheated steam, on account of [illegible] of the cylinder expanding more than the bottom, and [illegible] a considerable number of instances this has caused the rotating blades to come in contact with the cylinder, thereby being ripped out.

In the Allis-Chalmers design it was sought to overcome the distortion of the cylinder by such a distribution of the metal as to cause nearly equal expansion of the top and bottom of the cylinder, but at the same time the turbine drum was placed slightly above the center of the cylinder to assist in preventing contact of the blades in case of distortion. When the turbine was opened up, however, it was found that the compensation for distortion had been slightly overdone, and the cylinder had sagged a small amount, and this, together with the high position of the drum, had caused the blading to rub hard for nearly a third of the length of the turbine. With the older types of construction such contact would immediately have made itself manifest by the noise of the rubbing blades, and the blades would have been ripped out before the turbine could be stopped. In the Allis-Chalmers turbine, however, there had, while in operation, been no indication of the blades rubbing and no damage whatever had been caused; the only sign of contact having taken place was a slight wearing away of the flanges of the channel-shaped shroud ring which protects the tips of the blades in the Allis-Chalmers construction, and which is one of the most valuable patented improvements which that company has introduced.

The only precaution taken before starting up again to help carry the Coney Island load on April 1 was to lower the drum a few thousandths of an inch at each end. So far as known this has prevented all further rubbing, and the turbine has been in daily operation ever since, and has not again been opened.

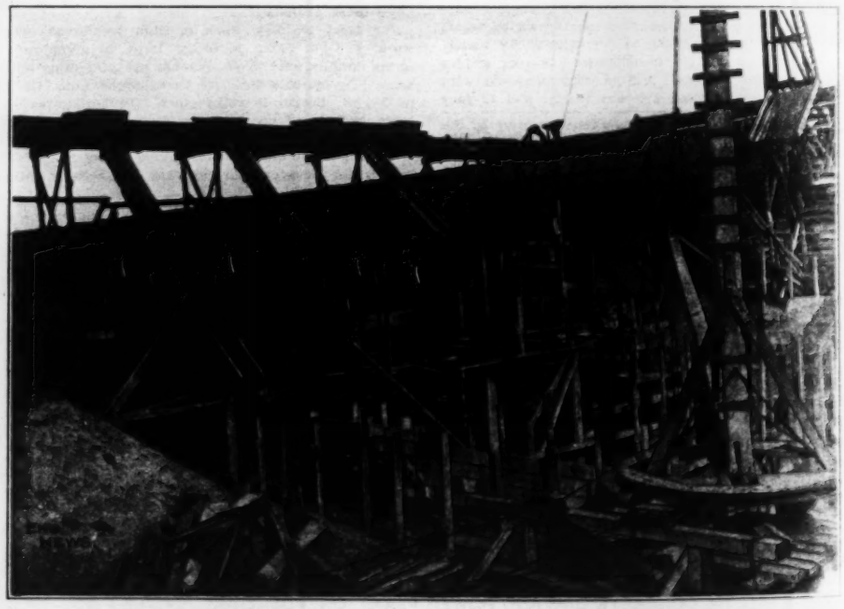

FIG. 4. BUILDING CONCRETE POWER HOUSE WITH TRESTLE AND CHUTES ON THREE SIDES. TURNTABLES ON CORNERS. TRESTLES 40 FT. HIGH ABOVE BASE OF FOUNDATIONS.

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It has already been made clear in the articles on the California earthquake, which have appeared in these columns, that different portions of the city of San Francisco were affected very differently, and that the buildings most seriously injured by the quake were those located on soft ground areas. In the San Francisco "Chronicle" of May 20, Mr. Wm. Ham. Hall, M. Am. Soc. C. E., reported a detailed survey of street subsidences which he has made in the lower parts of the city, and its comparison with a coast survey topographic map of 1857, which showed the tidal marshes and estuaries that then existed. The results of this comparison are expressed by Mr. Hall as follows:

> The writer has demonstrated that every subsidence or movement of note caused by the recent earthquake is either just along the edge of or within an area which formerly was swamp, salt marsh, mud flat or bay estuary in character. It is interesting to see how the platting of the earthquake's footmarks of this kind in our streets of to-day outlines the limits of the former soft spots of the formations on which San Francisco was built, and how the specially soft spots are again revealed by the greater movement now presented.

Mr. Hall then makes a detailed showing of how various notable depressions in the streets are due to the shaking down which the earthquake gave to great masses of filling material. For example, he says:

> One cannot but feel glad that the new Post Office building escaped, though barely, being in the area of depression which was once the site of Mission Bay and adjacent marshes. As a San Franciscan who knew this spot fifty years ago, who saw it a marsh with a little stream running through it, who saw hunters wearing gum boots, tramping about shooting jacksnipe in that very area, who later saw it drained for market gardening, and still later saw it filled to a depth of ten or fifteen feet with sand dumped off a bank from side dump cars, and then saw it occupied by light wooden houses for a score and a half of years, it seems entirely natural that a real earnest earthquake should make it settle and move just as it has settled and moved. It never had an inducement to get down to a good bearing before. Now it has been shaken to where it will probably stay, and San Francisco will be the better for it.

Not only vertical movements, but large lateral disturbances are traced by Mr. Hall to the movement of filled-in lands. Many of these fills were made upon hard, steep hillsides, and the lateral shake and settlement, of course, caused the fills to slide downward on the underlying strata. At some places, according to Mr. Hall, lateral movements of as much as 6½ ft. were produced in this way.

These facts deserve to be kept in mind by those who would carefully study earthquake conditions. The actual movement of the rock crust of the earth appears to be an elastic vibration, chiefly horizontal in direction; but the movements which occur where the rock is covered with a deep layer of earth, or other soft material, are very different, and it is in such places that the greatest vertical and lateral displacements occur.

The year through, what percentage of the contents of a technical journal are of interest to the average reader? The question has been raised by a subscriber who states that only about 40% of the contents of this journal interest him, and that he has been thinking of dropping it and subscribing for *two* others that pay more attention to the subjects in which he is interested. He finally concluded, however, to "try it one more year," adding that "perhaps there will be an improvement." We feel highly complimented by the proposal to substitute two other journals to better the 40% of interesting matter published in our columns, and by the final conclusion not to make a change at present.

Taking the run of periodical literature it seems very unlikely that the average man actually reads anything like 40% of what is laid before him each day, week or month. The more diversified the journal the more numerous will be the classes of readers to whom it appeals and the smaller will be the percentage of matter read by a large portion of its subscribers or purchasers.

But there will always be a goodly percentage of broad-minded, progressive readers who will value a journal quite as much for the part of its contents outside as within their specialized field of work or interest.

The engineer, of all men, cannot afford to confine his reading, even though for a time he does his practice, to one highly specialized line; at least, only a few top-notch specialists can reasonably hope to make a professional success by such a course, and success of that order is generally achieved at the sacrifice of general mental and social development.

The mass of engineers must be prepared to undertake a wide range of work within one or the other of such great divisions as civil, mechanical, electrical and mining engineering, and many of them must stand ready to step from one to another of these grand divisions at any time. The ability, natural and acquired, to make rapid changes of this sort is the key to success. So far as that ability is acquired, rather than natural, it will depend largely upon keeping well posted in general engineering. The specialist must generalize. He may know, or aspire to know, everything of something, but he should also aim to know something of everything. In so far as the latter is possible one of the chief means of its accomplishment will be the utilization of the technical journals; several journals of diverse character rather than one, but the smaller the number the greater the necessity to choose one that covers, as best it can, the whole field of engineering.

Reverting to the quandary of the subscriber who came so near substituting two other journals for this one because so large a part of our contents did not appeal to him, we would emphasize the fact that it is a mistake to suppose that the most highly specialized journal can place before all or even a bare majority of its readers a table of contents that will interest them from end to end. Each reader, and this holds good to some extent of all journals, will find in every number of the specialized journal more or less matter that to him is elementary, or old, or trivial. Subscribers to the more general papers will find in them less matter of these sorts, because the many subjects treated cause so great a pressure upon their space as to exclude most that is elementary, repetitive and trivial. Some elementary matter, however, will be included, in order to meet the wants of the younger men and of such of the older readers as may be reaching out into unfamiliar fields. Finally, no technical journal can be judged on its weekly interest to its readers. No small part of its value lies in its availability for future reference; and what an engineer may be most deeply interested in next year or five years hence may make no appeal to him when it first meets his eye.

WHAT IS WORTH WHILE?

We published in our last week's issue the report of the Senate Canal Committee favoring a sea-level canal at Panama. No action has been taken on this report and Washington advices state that sentiment in the House is so strongly adverse to the sea-level canal and favorable to the lock canal that even should the Senate approve the majority report of its canal committee, the result would merely be a deadlock between the two houses of Congress. There appears to be good reason to believe, moreover, that the same interests which have for years exerted their influence to delay or defeat the canal enterprise are now ranged on the side of the sea-level plan. They can in this way pose as friends of the work and their ends would be attained if the date of completion could be so long postponed and the cost of construction could be so increased that the public when the next season of hard times comes along—when a million dollars will look as large as ten million does in these flush days—would confess itself sick of the whole job, and vote for its abandonment.

We do not, of course, anticipate such a result, even if the sea-level plan were adopted; and very likely the interests referred to do not really expect such success. But while unable to longer prevent the canal work and not daring to openly oppose it, they can safely work for a plan of construction which will postpone to the latest possible date the completion of the canal and will involve as many difficulties as possible in its construction.

Besides the above class of advocates of the sea-level plan, there are, of course, others who are carried away by what may be called the sentimental argument in favor of the sea-level plan, and who honestly believe that plan to be the better one for the United States to adopt.

In the current discussion of the two plans which has gone on during the past six months, the public attention and to a considerable extent the attention of engineers as well has been fixed on particular features of the problem. We wish now to present the question from a different and we hope a broader standpoint.

In the first place the engineering profession as a whole, we take it, will unhesitatingly agree that it is perfectly practicable to build a successful canal at Panama on either the lock plan or the sea-level plan. It is a big task, of course, on either plan; but yet it involves nothing impossible or experimental or uncertain. Difficulties will arise, of course, as they arise on every engineering work, great or small; but they involve nothing that cannot be met and overcome; and no work is proposed for which good and sufficient precedent does not exist.

We believe this point is worth especial emphasis, for a popular impression seems to be abroad that the canal work is a sort of fearful and wonderful piece of engineering, which may succeed or may fail and no one can tell which. The fact is, of course, that the only fearful and wonderful thing about the Panama work is its size. As a whole its engineering problems are relatively simple. There was more of doubt and uncertainty and unsolved problems in making a tunnel entrance under the North River to New York City for the Pennsylvania R. R. than in the whole Panama work.

This fact, we take it, is clear enough to engineers, particularly now that the preliminary work has been so thoroughly accomplished and that the sanitary and living problems have been so well solved. Admitting, then, that either canal can be successfully built, the question arises whether the sea-level canal would be enough better than the lock canal to be worth the admittedly greater cost in money and in time.

We are well aware that the sea-level advocates treat the question of relative cost as if it were of no importance whatever. The majority report of the Senate committee was quite severe on the engineers of the Consulting Board for referring to the matter of relative cost at all. We maintain that this position, whether held by layman or engineer, is unscientific and absurd. There must be a relation between the value of

a sea-level canal over a lock canal and its extra cost. If some vast benefit is to accrue to the nation or the world by the making of a salt water channel all the way across at Panama, then it may be proper to spend the money necessary for such a channel. If on the other hand the lock canal is practically as useful for commerce and the sea level canal offers only trivial and unimportant advantages, then by all means let a hundred millions, more or less, of the taxpayers money be saved to them; or if forsooth, Uncle Sam is so rich that he must spend it, let it be laid out on some of the great public works within our own borders, such as the canal for the lake shipping from the Great Lakes to tidewater, a work which would probably be more beneficial to the country as a whole than the Panama Canal can ever be.

The question to be settled, then, is whether the sea-level canal is worth while; and this raises at once the question, What does the passage through locks involve? Will the passage through the locks be any real and practical detriment to the Panama route? To ask such a question is almost to answer it. Not a vessel will ever pass around the Horn instead of through the Panama Canal because of the locks there. The Senate committee itself estimates that only four to five hours would be required for the passage of all the locks on the Panama Canal. Practically all the vessels using the canal will do so in the course of a voyage measured by thousands of miles. A delay of four or five hours in the course of such a voyage is the merest trifle and in addition it must be remembered that the delay in the locks is almost or quite balanced by the more rapid passage in the open lake navigation of the lock canal as compared with the narrow ditch of the sea-level canal. Certainly, then, there is nothing in the matter of vessel movement to make a sea-level canal worth while.

The Senate committee report which we printed last week declares that the sea-level canal will be much *safer* than the other. The basis for this assertion rests on a hypothetical assertion by some of the sea-level advocates regarding the *possibility* of accident to a ship in passing through a lock. Such possibility may be freely admitted; but an exaggerated idea appears to have become current regarding the actual degree of danger.

Is a ship really in danger in passing through a canal lock? If it is we may be sure that that danger will be directly reflected in the premiums charged for marine insurance; but the Senate committee itself states that the insurance rates on vessels passing the locks on the Manchester and the Soo canals are no higher than on vessels engaged in ocean commerce. The fact is there is no reason why insurance rates *should* be higher for vessels navigating ship canals. The risk to vessels from storm, from fog, from grounding, from accidents to machinery are a thousand times greater, experience shows, than the vague and remote possibility of accident in a canal lock.

The plain, solid fact, founded on experience in the movement of many thousands of vessels and many millions of tons of freight, and not on theory, is that there is no appreciable danger to vessels in a canal lock. Vessels are all the time entering dry docks and wet docks and passing in and out of slips between piers where they are as much exposed to injury as they would be in a canal lock, and yet such movement is taken wholly as a matter of course.

It seems little short of absurd, therefore, that the danger of passing through canal locks should be considered a valid argument for a sea-level canal. If it were valid, then no more ship canals with locks in them ought ever to be built.

One would suppose, to read some of the discussion on canal types that a ship canal with locks had never before been built; but the actual fact is that the Manchester ship canal with its four locks has been in operation for twelve years and has been used by a very similar class of vessels to those which will use the Panama route. In this country the great Poe Lock at the Sault has been in use for ten years, and the Canadian lock at the same place nearly as long. The records of growth of traffic and size of vessels passing through the Sault Canal is the best possible proof that, sentiment aside, the passage through locks is no real obstruction to the movement of traffic or the growth of commerce. A notable illustration of this is the very recent announcement that new ore-carrying lake steamers are shortly to be contracted for to be 640 ft. in length and capable of carrying 14,000 tons of ore; in other words, vessels rivalling in size the largest class of ocean steamers and larger by far than the average vessels likely to make use of the Panama Canal.

Everybody admits of course that vessels of ordinary size can pass through locks without any particular difficulty or danger. This *must* be admitted because such vessels have been passing through locks in all parts of the world for half a century past. The contention of the sea-level advocates, however, is that when we come to very large vessels and very large locks, what before was simple and easy becomes doubtful or impossible. Is this true? Is the great Poe lock at the Sault any less successful and practical than the small Weitzel lock? If it were, then the opponents of the lock plan at Panama might have some ground to stand upon; but as a matter of fact the Poe lock has been so thoroughly successful that plans have been made for a still larger lock at the Sault, 1,400 ft. in length, on the site of the old Weitzel lock. This is planned for, it should be said, not because the Poe lock is not large enough for the largest vessels, but because with the system of towing so extensively practiced in the ore trade on the Great Lakes, a longer lock can take in all the vessels of a tow without uncoupling, and thus expedite the movement of traffic.

The Senate committee's majority report, printed last week, accepts the estimates of future traffic at Panama, given in our issue of April 19 on the authority of Prof. Johnson at 7,000,000 tons in 1914. There can be no possible question, therefore, that the lock canal will have a traffic capacity equal to all demands upon it until a period too far in the future to be now foreseen. The ocean commerce which would be facilitated by the canal will use that route just the same whether the canal be at sea-level or with locks. What then will be the practical gain to the United States in return for its expenditure of a hundred to a hundred and fifty million dollars additional and a half dozen years more of time to make a canal at sea level instead of one with locks? Our opinion is, after a most careful study of all the arguments on both sides, that there is no practical advantage in the sea-level plan that makes it worth while.

Finally let us revert again to the sentimental side. It has been brought forward as an argument by the sea-level advocates that American engineering ought to pause at no obstacle; and that it would be in some sort a reflection on our engineering talent and thus on the nation if we fail to dig the isthmian barrier entirely away and unite the two oceans.

There is, however, another aspect of this. Is it not a mark of the greatest engineering to accomplish great tasks with the least outlay of money and time? Is this not indeed a distinctive mark of American engineering, which has been roughly defined as the art of making a dollar earn the most interest. A very primitive people might, in the course of years, dig through the Culebra divide, as the Mexicans hundreds of years ago dug the great cut of Nochistongo to protect that capital city from floods because their engineering ability was unequal to the making of an efficient and durable tunnel.

If we were to dig a sea-level canal at Panama, it would rank, considering the resources in power and machinery now available, not much greater as an engineering feat than the building of the now almost forgotten cut of Nochistongo.

But if on the other hand American engineers go to Panama and at a small part of the cost of digging a ditch at sea level clear across the Isthmus, create a great inland lake, by which the Chagres River, long the insurmountable obstacle to the transit of commerce [illegible] Isthmus, shall be made to bear the [illegible] nations in a safe and speedy passage [illegible] to ocean—that were a feat well worthy [illegible] and one certain to reflect perpetual [illegible] the American engineering profession.

LETTERS TO THE EDITOR.

Benzine for Cleaning Tracings.

Sir: I would like to know if the use of benzine, in cleaning tracings, is in any way injurious to the tracing. Also to what extent this is practiced in the drawing rooms. Yours truly,

Rutherfordton, N. C., May 18, 1906. [illegible] Rader.

[The sponging of tracing cloth with a rag saturated with naphtha or gasoline or benzine does not injure the cloth or the ink lines. The least. It, however, has the effect of freshening the color of a much handled and soiled tracing, and will remove pencil lines perfectly. While a certain compound which is being used for removing ink-lines on tracing cloth will occasionally leave a sticky or gummy kind of surface, the application of benzine will quickly dry the affected portion, so that it can be worked over again. If any readers have found any injury resulting from the use of benzine we should be glad to hear from them.—Ed.]

A Protective Coating for Well Casings for Alkaline Waters Wanted.

Sir: I have read with much interest the discussion on the subject of protective coatings for water pipe, especially that in Mr. Allen's letter in Engineering News of May 17, concerning the corrosion of a riveted steel water main.

In this locality much trouble has been experienced on account of the rapid corrosion of artesian well casing, necessitating frequent and expensive renewal. One well, having a diameter of 8 ins., is cased to a depth of 1,172 ft. with wrought iron pipe with threaded joints. The well has a flow of 800 gals. of water per minute, accompanied by a discharge of natural gas. The water, after passing through a gasholder, is allowed to flow off into the Missouri River; the gas is caught and is used throughout the town for light and fuel purposes.

The water is mineral saline, containing large quantities of salts of sodium. Its effect upon the well casing is quite destructive, so much so that the iron becomes honeycombed in about 3½ years after being put down. Various remedies have been suggested, but no practical method of preventing such rapid corrosion has been found. If some protective coating, that would be effective for preserving or prolonging the life of the iron pipe, could be found, it would be of great value to this locality. Yours truly, Samuel H. Lea,

State Engineer, South Dakota.

Pierre, S. Dak., May 21, 1906.

The Hill Plan for Excavating the Culebra Cut.

Sir: The plan suggested by Mr. Hill for excavating the Culebra cut on the Panama Canal in your last issue is not entirely novel. Very much the same plan has been in use at the Treadwell gold mine, Douglas Island, Alaska. There is there a tunnel some 600 ft. below the original surface, if I remember rightly. This tunnel is provided with tracks for cable cars, and at intervals there are "glory holes," shafts from the surface to the tunnel, fitted at the bottom with ore chutes. The rock is blasted in a circle about these holes and dropped into them, and thence into the cars, which are hauled up an incline to the crusher house, which is on a hill above the surface of the ledge being worked.

It is a low grade free milling ore, and the necessity of some cheap means of working it was probably the reason for the adoption of this plan.

Yours, J. M. Diven.

14 George St., Charleston, S. C., May 18, 1906.

[The so-called "milling" process of excavation to which our correspondent refers is in fact quite widely used in iron mining. It has been used in the Mesaba iron district both for milling ore and for removing the overlying earth from ore bodies. It is important to note, however, that open excavation with steam shovels has been found more economical than the milling system and has therefore largely superseded it on the Mesaba range.—Ed.]

Multisecting Angles.

Sir: ... from recent issues of Engineering News the ... uld do well to prepare for trouble. When the w... editing a technical journal some years ago he al... short item regarding the trisecting of an angle ... rinted, and he was immediately overwhelmed with ... os" from numerous cranks, all of which were ... publication for the following reasons:

I. T... blem cannot be solved, using only the straight line ... cle.

II. A ... number of solutions are possible by the use of any ... conic sections or of higher plane curves.

III. ... lution is of no value, unless it provides a means ... ultisecting an angle, i. e., dividing it into any numb... qual parts.

Alth... n exact geometrical solution is impossible, a very ... pproximation will answer all practical purposes ... draftsman, provided the error cannot be detected ... ordinary instruments of measurement. In an article ... ished in No. 1, Vol. I., of the Engineering Journal ... ed by students of Stanford University, H. F. Blichfeldt ... shows how to protract any angle from 0° to 60°, using ... the compasses, the straightedge and an ordinary ... The construction is readily reversed, and affords ... mple means of measuring an angle with the scale. ... means of this construction angles may be multisected ... or divided proportionally almost as easily as straight lines; the error is negligible, and the accuracy of the result depends only on the skill of the draftsman. The demonstration is too long to be given here, but it may be found in the journal referred to above.

C. J. J.

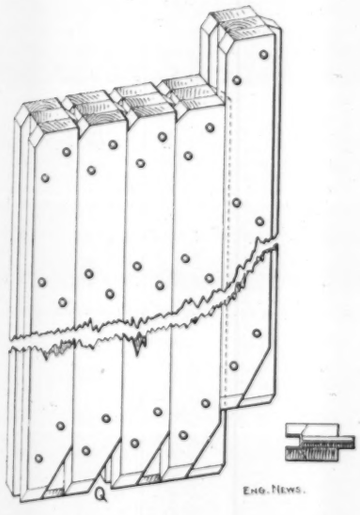
Scranton, Pa., May 17, 1906.

[For practical purposes a protractor and a little arithmetical calculation would appeal to us as the best method for the draftsman to use in multisecting an angle.—Ed.]

An Improved Scarfed Point for Sheet Piles.

Sir: While looking over some old papers I ran across a sketch which I made some ten years ago, thinking, at the time, that I would apply for a patent. I enclose the same to you, thinking it may be of interest to some of your readers.

In actual practice I will say that the device has saved me no end of trouble in places where sheet piling was driven to rock and excavation made on one side, also in cutting off streams of water that followed on top of rock under embankments, etc.



Sketch Showing an Improved Scarfed Point for Sheet Piles.

I have used the point on 12 × 12 ins. sawed piles as well as triple lap sheeting. It is easily made with a cross cut saw, and insures a tight and uniform bottom which cannot be had where piles are scarfed to make them hug each other.

Yours truly,

Waterford, N. Y., May 5, 1906. A. A. Parker.

[In explanation of the drawing it may be noted that the object is to sharpen the pile in such a manner that there shall be no hole between the piles at their points after driving, while at the same time giving the pile point the required scarf to make them hug each other while being driven. The opening marked Q on the drawing shows the hole left between piles when scarfing is resorted to in the usual manner. The places marked P on the drawing show the hole closed by using the Parker pile point.—Ed.]

Effect of California Earthquake on Concrete Block and Reinforced Concrete.

Sir: Noting in your issue of May 10 the picture of the wreck of a concrete block building in Palo Alto, Cal. I have thought that the accompanying view might interest your readers. The collapsed gable shown was 80 ft. long and 25 ft. high in the center, and was built of 12-in. hollow blocks. The earthquake shock of April 18 was in the direction of the length of the gable.

Like to the power house stack at Stanford University, the upper portion of the wall fell on one side, while the lower half fell on the other, and the swaying motion of the shock is clearly evidenced by the way the wall lies as a whole, the doors being sharply outlined and even the centering lying in place. The gable had been completed by the contractor some two weeks before the shock.

The blocks were a 1 : 4 mixture, hand tamped and laid in half lime, half cement mortar. The side walls of the building were cracked in one or two places, and many of the joints loosened; the other gable had not yet been erected.

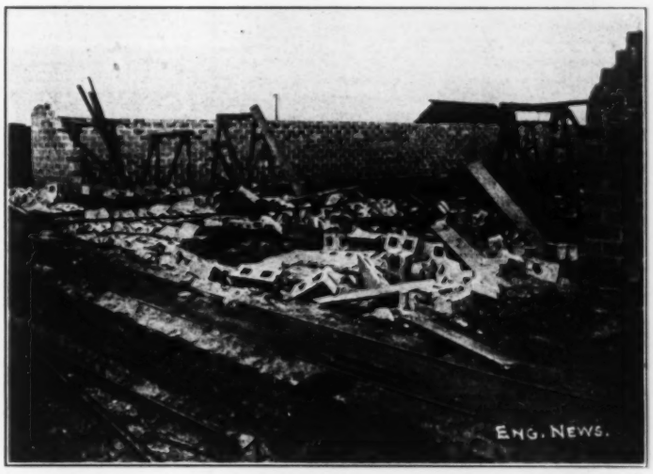
Near the collapsed wall were three large buildings built of concrete on the "Ransome" hollow wall system, and reinforced with twisted bars, and none of these showed any cracks whatever. Also, a building being erected by the writer, similar to these, and in which some of the concrete had only been placed four days previously, was uninjured.

A 75-ft. tank trestle, supporting a 100,000-gallon tank full of water, was also uninjured, though the night watchmen stated it swayed several feet in either direction and water was spilled for 50 ft. either side of the base. Black Diamond, I might add, is 50 miles east of San Francisco and 60 miles north of San Jose.

Yours truly,

O. P. Shelley, Jun. A. S. C. E.

Black Diamond, Cal., May 19, 1906.



EFFECT OF CALIFORNIA EARTHQUAKE ON CONCRETE BLOCK BUILDING AT BLACK DIAMOND, CAL.

A Graphical Method for Laying Out a Five-Centered Arch

Sir: Referring to Mr. Swartz's solution of the five-centered arch, in your issue of May 10, may I suggest that a simpler formula for the intermediate radius is,

$$R_2 = \sqrt{\frac{a\,b}{2}}.$$

For, $R_2 = MI = ND = CE$.

But $\overline{CE}^2 = AC \times CP = \frac{a\,b}{2}$

$$R_2 = \sqrt{\frac{a\,b}{2}}.$$

Or the same value may be obtained by reducing Mr. Swartz's formula as follows:

$$R_2 = \sqrt{\left[1 - \frac{(\frac{1}{2}b - a)^2}{(\frac{1}{2}b + a)^2}\right] \frac{(\frac{1}{2}b + a)^2}{4}}$$

$$= \sqrt{\frac{a\,b}{2}}$$

There is a typographical error in the formula for cos K O M, the denominator of which should read 2 O K × O M.

Yours sincerely,

Jonathan Jones.

University of Pennsylvania, Philadelphia, Pa., May 10, 1906.

Sir: In your issue of May 10 I notice a solution of the five-centered arch problem, by Mr. A. Swartz. The solution of this problem is given in "Warren's Stone Cutting and Stereotomy" in almost the identical form, except that in his hypothesis Prof. Warren uses the ratio $\frac{a}{b}$ as a given quantity equal to ¼, thus making a much simpler solution. He also gives the solution of a general case for an oval having any number of centers.

Sincerely, T. H. Brown.

Pittsburg, Pa., May 12, 1906.

The Design of Rim-Bearing Turntables for Swing Bridges.

Sir: Emerson said that all his life he had wanted to write an essay on "Compensation." He wrote one at last, and it has become a classic. With a much less degree of inspiration and output I have wanted for some time to say something about rim-bearing drawbridges. The article on "The Design of Swing Bridges," by Mr. C. H. Cartlidge, in your issue of April 26, gives me my cue.

To my surprise Mr. Cartlidge expresses a predilection for the rim-bearing type. The writer confesses that he agrees with Mr. Cartlidge, probably contrarywise, with the opinions of most engineers, but the writer does not approve of the rim-bearings shown in the illustrations to Mr. Cartlidge's article.

The design of a bearing for a drawbridge, whether rim or center, is a matter outside of bridge engineering proper, and belongs more precisely to the domain of mechanical engineering. While he does not claim to be a mechanical engineer, the writer has had much to do with machinery, and has, of necessity, been prodded by some of its most salient points.

Starting with the track on which the conical rollers move, this is shown in the illustrations referred to as being a few inches high, its top surface depending on the accuracy of the plane of the stonework beneath. It is absolutely impossible to set a circular track in this way with a reasonable degree of accuracy. Then the circular track is anchored to the masonry by bolts, presumably set to a circle by the erector; here is another element to cause trouble. In other words, the masonry of the pier is made part of the machine. Five minutes in a machine shop will convince any one that after long experience machine builders make their machines self-contained and give them a foundation sufficient to support their weight without any intermingling of foundation and machinery.

To be in line, then, with mechanical practice and to make an efficient rim-bearing for a drawbridge there should be, first, a drum capable of holding the lower circular track to true line and surface. Such a drum will, of necessity, bear on the masonry at three points for the fewest possible, and should be stiff enough to carry the dead weight of the bridge with this support.

This drum, with its circular track securely fastened on, should be set on a mill large enough to take it, and the track should be turned to a true circle with proper bevel to top surface. Facets should be provided on its inner face, and these should also be turned to the same center to receive the outer ends of struts holding the center spindle in place. This spindle should be set at the same time on the same mill, and should also have facets turned off true to receive the inner ends of the aforesaid struts. These struts should be so arranged as to hold the center spindle in place within the drum and should be absolutely without adjustment. They must prevent the center spindle from having any lateral displacement or tendency to overturn. All the erector will have to do will be to put the whole together precisely as it was on the mill, which he cannot avoid doing, and then fill in any vacant spaces between the drum and its masonry support. In this way a self-contained base to the rim-bearing center can be had on the lines correctly laid down by mechanical engineers.

Above this support come the conical rollers. These can easily be turned to a true taper, but it is impossible to give them their proper diameter by calipers. The way to do this is to put each roller, after turning into a cast-iron socket, faced inside to the same taper, and from the same socket mark the point to which each end of the roller hub must be faced in order that at a given distance from the center spindle each roller shall have absolutely the same diameter. Struts should then be provided from each roller to the center spindle, and these struts, like all else connected with the machinery, should be without any means of adjustment whatever.

On the rollers comes the upper track. This should be

turned and strutted to the center spindle the same as the lower. As it is always possible to make the superstructure bear on this drum at eight points instead of three, as in case of the lower drum, by suitable arrangement of cross and longitudinal girders, the upper drum need not be as stiff as the lower.

The four verticals of the superstructure near the center should be so supported that no live load will come to the center except from the panel above it. If other than hand power is used there should always be at least two points of application to the circular rack properly equalized. This rack should also be attached to the lower drum, not to the masonry.

A drawbridge with a center design on these lines will revolve about a fixed point, and in a plane, horizontal or otherwise as may be desired. With a center-bearing support the bridge will not so revolve as regards the plane, except as held by the uncertain action of idle rollers to hold it. The weight is better distributed over the pier by the rim-bearing, and, as before hinted, it is the opinion of the writer that much of the criticism unfavorable to rim-bearing drawbridges is due to incorrect design.

Chas. C. Wentworth.

Roanoke, Va., May 19, 1906.

Notes and Queries

In the paper on gas producers for power purposes by Mr. Oskar Nagel, on p. 538 of our issue of May 17, reference was made in connection with the illustration, Fig. 1, to the use of a boiler in connection with the producer. This reference was an error as the cut referred to showed a producer plant equipped with a rotary fan to furnish draft instead of a steam jet blower from a boiler, as described near the bottom of the middle column of the page referred to.

RECENT RAILWAY VIADUCTS OF REINFORCED CONCRETE.

Concrete bridges with large arch spans, and concrete culverts or openings of small span (with arch or flat tops) have become so numerous and are being so extensively adopted that they represent an established system of construction, and are now notable individually mainly for special details or features of design and construction. An intermediate class of structure is the concrete viaduct or trestle, composed of a series of short spans, and used in cases where timber or steel trestles, or steel girders on masonry piers, would ordinarily been employed. We have recently received information from two railways in regard to structures of this class, one road using a concrete girder construction, and the other a concrete arch; in both cases the concrete is reinforced with corrugated steel bars.

CLEVELAND, CINCINNATI, CHICAGO & ST. LOUIS RY.

Probably the most striking example of concrete viaduct construction of the type above mentioned is on the Cairo Division, near Lawrenceville, Ill., where three of these structures have been built to carry the line across the Lawrenceville bottoms. These were built last year in connection with the extensive grade revision and general improvement work upon the entire length of this division. The three structures are all of similar construction except as to their length, consisting of a series of 20-ft. spans, with reinforced concrete girders and a flat floor. The longest has a total length of 1,217 ft. 9 ins. (52 spans), and the others are 739 ft. and 280 ft. 9 ins. long (with 32 and 12 spans, respectively). Fig. 1 shows the general design, and Fig. 2 shows the details. It will be seen that each span has girders 5 ft. 4 ins. deep and 2 ft. wide, connected at mid-depth by a flat floor 21 ins. thick. The arrangement of the reinforcing bars is clearly shown. For the sake of appearance the faces of the girders and piers are relieved by paneling, as shown.

On each abutment and on every fourth pier there is a horizontal expansion joint, movement in which is provided for by transverse inverted

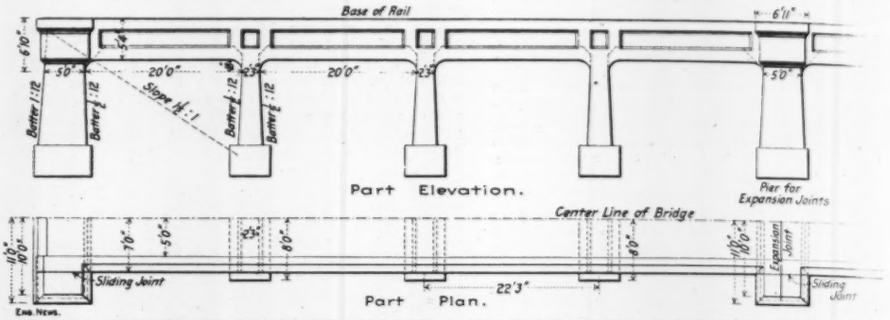


FIG. 1. REINFORCED CONCRETE VIADUCT WITH FLAT SPANS; CLEVELAND, CINCINNATI, CHICAGO & ST. LOUIS RY.

Geo. W. Kittredge, Chief Engineer. W. M. Duane, Superintendent of Construction.

rails embedded in the upper portion and resting upon short lengths of rails embedded in the concrete of the pier itself. To ensure a clean contact between the rails, those of each course project ⅛-in. from the face of the concrete, forming a ¼-in. open joint between the girder and the pier, which is filled with layers of felt. At each fourth pier also, there is a vertical expansion joint in the floor and girders. This is filled with two layers of felt reaching to within 2 ins. of the top, the upper portion being filled with asphalt. In addition to these, there are vertical expansion or sliding joints between the girders and the upper part of the piers. The details of these three styles of expansion joints are shown in Fig. 3.

These structures were designed and built under the direction of Mr. Geo. B. Kittredge, Chief Engineer, and Mr. W. M. Duane, Superintendent of Construction. The contractors were Moore & Mansfield, of St. Louis, Mo.

Three grades of concrete were used for the footing, the piers, and the floor and girders, as indicated on the drawings. The mixtures for these grades were as follows:

	Proportions			Quantities per cu. yd. of concrete		
	Cement	Gravel	Stone	Cement bbls.	Gravel cu. ft.	Stone cu. ft.
Class B. Footings	1	9½	0	0.75	27	0
" D. Piers	1	6⅛	0	1.08	27	0
" E. Girders and Floor	1	2	4	1.50	12¼	24½

ILLINOIS CENTRAL RY.

On this road short concrete viaducts or trestles of the form shown in Fig. 4 have been built, having elliptical arches of 14 ft. clear span and 4 ft. rise. The longest of these has five spans, and its total length is 87 ft. 10¾ ins. The arch is 16 ins. thick at the crown, with parapet walls 10 ins. high, and the base of rail is 8 ins. above the top of the walls. There are no expansion joints, these being required only in structures of over 100 ft. in length, which are divided into sections of approximately 25 ft. by means of such joints. These viaducts were designed under the direction of Mr. A. S. Baldwin, Chief Engineer, and Mr. [illegible] Gaut, Engineer of Bridges.

The concrete is made of crusher-run stone and is mixed quite wet. In the pier foundations the proportions are 1-3-6, while the arch rings and slabs they are 1-2-5. The molds or forms for finished or exposed work are required to have dressed surfaces, which must be soaped or oiled if necessary, to give a smooth finish to the concrete. For the facing of such work the specifications provide that a mortar facing of 1 cement (by measure) to 2 sand shall be put in next to the molds to a thickness of 1½ ins.; this thickness is secured by the use of a piece of sheet iron 6 ins. wide (the height of one layer of concrete) having vertical 1½-in. angles riveted to the outer side to keep the plate 1½ ins. from the mold. The mortar facing is first filled in between the plate and the mold, and when the layer of ordinary concrete has been filled in the plate is withdrawn and the whole mass of concrete rammed in one layer. The facing mortar must be thin enough to flow, but not so thin as to allow the crushed stone to be forced through it to the surface during the process of tamping.

PROTECTING MUNICIPALITIES AND INDIVIDUALS AGAINST DIRECT AND INDIRECT DAMAGES ON ACCOUNT OF EXTENSIONS TO THE NEW YORK WATER SUPPLY.

The approval of the plans for the proposed Catskill water supply for New York City was noted on p. 589 of our issue of May 24, 1906. A supply of some 500,000,000 gals. a day at an estimated cost of $162,000,000 is proposed. In its report, approving the plans, the State Water Supply Commission stated that it is directed by statute to determine:

(1) Whether the plans proposed are justified by public necessity;

(2) Whether such plans are just and equitable to other municipalities and civil divisions of the state affected thereby and to the inhabitants thereof; particular consideration being given to their present and future necessities for sources of water supply, and

(3) Whether said plans make fair and equitable provisions for the determination and payment of any and

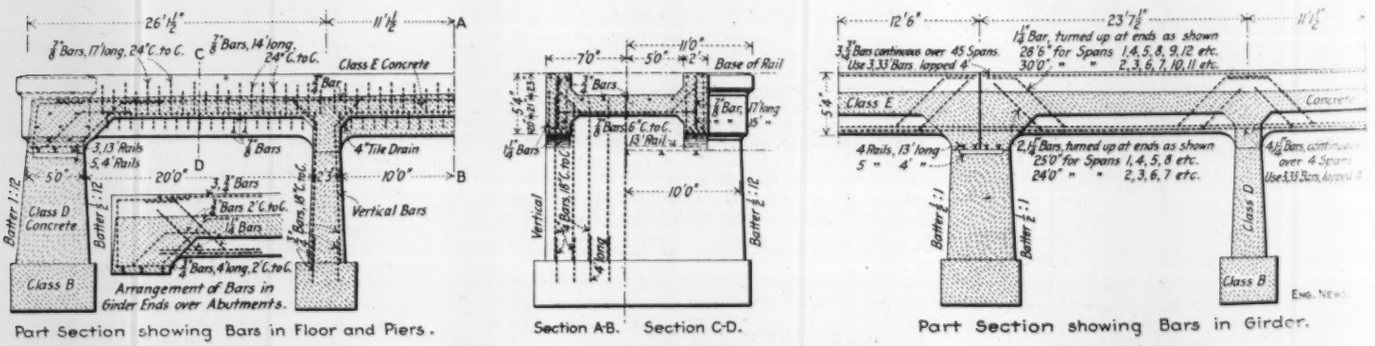


FIG. 2. DETAILS OF CONCRETE VIADUCT.

all damages to persons and property, both direct and indirect, which will result from the execution of said plans.

The main conclusions of the commission under those three heads have been given, as noted above, but it seems desirable to give in more detail some of those portions of the report dealing with the precautions taken to insure that no injustice be done to communities, private corporations and individuals by the extensive takings of land and water for the development of the new supply for New York City. The report of the commission states that to protect the various interests affected it secured, with the approval of the City of New York, a number of amendments to existing legislation. Among these was one providing that a contractor for work in any municipality must give a $5,000 bond to that municipality to protect it from charges for paupers or indigent employees brought in by the contractor; that contractors must provide police protection and agree to meet the cost of any criminal actions or of any expense due to riots on account of their employees.

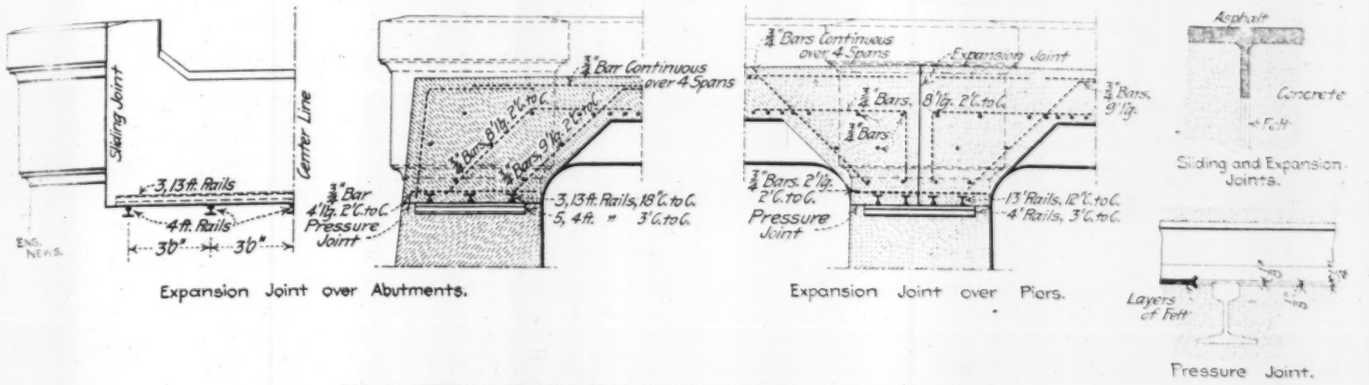
Inasmuch as the proposed Ashokan reservoir, alone, will submerge an area of 10,120 acres, and a length of seventeen miles in the Esopus Valley, destroying or causing the removal of all houses, business places, schools, churches, etc., etc., within the area, and affecting the employment of many people, special protection on this account was deemed necessary. Statutory amendments to this end are reviewed in the report of the commission as follows:

Sec. 11, Chap. 724, of the Laws of 1905, as amended in 1906, provides that before the City of New York takes possession of any of the lands necessary for the execution of its plans, it shall pay to the respective owner or owners of each parcel of real estate taken, a sum of money equal to one-half the assessed valuation of same, as it appears by the assessment role of the town in which the same is situate for the year 1905, and provides, that a deposit of the money to the credit of, or payable to the owner of such land, pursuant to the direction of the court, shall be deemed a payment thereon.

Sec. 37 of said act as amended provides that if the City of New York, or its representatives, shall enter upon any lands not taken in pursuance of said act, for the purpose of preserving streams or water courses from pollution or contamination, or for the purpose of removing or causing to be removed any building or improvements thereon, on the ground that the same may contaminate the water supply, it shall make just compensation to the owner of said buildings or improvements.

Sec. 42 of said act as amended provides that if any real estate, not taken by virtue of that act and Chap. 723 of the Laws of 1905, or if any established business on June 1, 1905, situate in the counties of Ulster, Albany or Greene, should be, directly or indirectly decreased in value by reason of the acquiring of lands by the City of New York for an additional water supply, or by reason of the execution of any plans for such additional water supply by the City of New York, under the provisions of said act and Chap. 723 of the Laws of 1905, the owner, his heirs, assigns or personal representatives, shall have a right to damages for such decrease in value, and that the commissioners, appointed to determine such damages, shall not be limited in the reception of evidence to the rules regulating the proof of direct damages. It also provides that a person employed in a manufacturing establishment or in an established business, or upon any lands, who is not the owner or part owner thereof, or of any interest therein, in the counties of Ulster, Albany and Greene, which manufacturing establishment or established business is injured or destroyed, or which lands are taken or acquired under or because of the provisions of said act, who has been so employed continuously for six months prior to Jan. 1, 1906, and who continues in such employment up to the time of such injury, destruction, taking or acquisition, shall have a claim for damages against the city of New York equal to the salary paid such employee for the six months immediately preceding January 1, 1906, and that an action to recover such damages, if they cannot be agreed upon, may be maintained against the City of New York in the Supreme Court, not, however, for an amount to exceed the sum of the wages paid the party claiming such damages for the six months immediately prior to January 1, 1906.

The amendments were prepared after consideration of the evidence produced and the arguments made by the attorneys representing the objectors upon the hearing; also after a personal inspection of some of the territory proposed to be taken and a study of the laws of the State of Massachusetts, and the method adopted by the Metropolitan Water Board of that State in dealing with similar questions; and the commission believes that the law as now amended makes fair and equitable provisions for the determination and payment of any and all damages, both direct and indirect, which may result from the execution of said plans, and that it also protects New York from paying exorbitant and improper damage.



Expansion Joint over Abutments. Expansion Joint over Piers.

FIG. 3 DETAILS OF HORIZONTAL AND VERTICAL EXPANSION JOINTS.

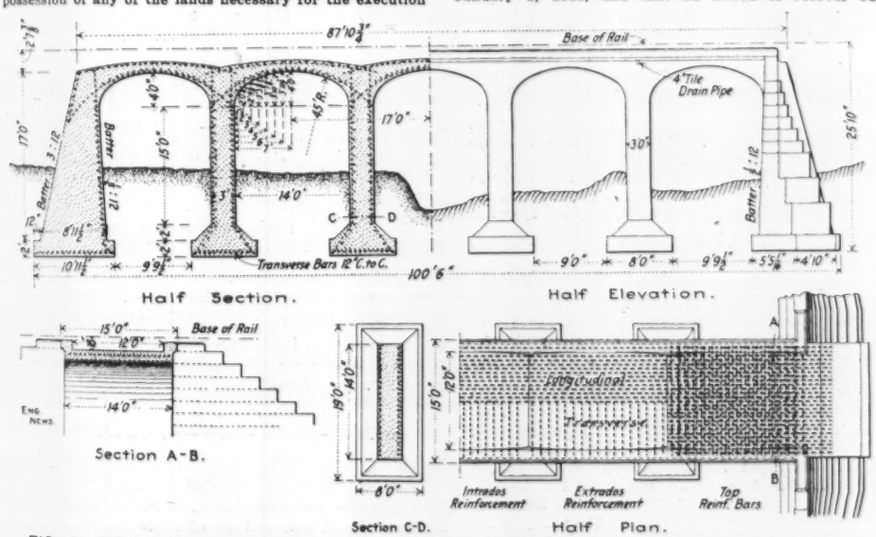


FIG. 4. REINFORCED CONCRETE VIADUCT WITH ARCHED SPANS; ILLINOIS CENTRAL RY.
A. S. Baldwin, Chief Engineer. R. G. Gaut, Engineer of Bridges.

REPORT ON THE DEFECTS OF THE BROOKLYN TUNNELS OF THE NEW YORK RAPID TRANSIT RY.

As noted in our last issue the defects in the East River tunnels of the New York Rapid Transit Railway extension to Brooklyn have been made the subject of a special report to the Rapid Transit Commission. The report as submitted by Chief Engineer Rice, of the Commission, shows that the settling of the shield and subsequent sagging of the tube in spots were first noted by the engineers two years ago and fully reported to the board at that time. Also that enough money has been withheld from the contractor to compensate for the reconstruction of the defective tubes. It will be necessary to reconstruct about 2,500 ft. of tube; but as portions of the south tube have already been rebuilt with great success, he predicts the completion of the tunnels ready for operation by the first of next year. The report is as follows:

The Hon. A. E. Orr, President Rapid Transit Board:

Dear Sir: In accordance with the resolution of the board at its last meeting, I present a report on the conditions of the Brooklyn tunnel, with particular reference to that portion lying in the borough of Brooklyn.

In the latter part of 1902, contract No. 2 for the Brooklyn extension of the Rapid Transit Railroad was let, and work was started in the early part of 1903. Shortly after the commencement of the work, complaints were received in reference to the settling of the buildings on Joralemon Street near Henry Street. The contractor employed the shield method in construction, which involved the taking out of material through the front of a cylindrical metal compartment, strongly built, weighing about fifty tons.

After the construction of a certain portion of the tunnel, the shield was pushed ahead by hydraulic power, and within the space included by the rear portion of the shield the tunnel tube was built of cast-iron plates, forming a tube of fifteen feet six inches internal, and sixteen feet eight inches external, diameter. By this means the tunnel was gradually constructed. There was no serious trouble in maintaining the grade of the tunnel until shortly after Garden Place was passed, when water was encountered in considerable quantities, and the shield commenced to settle below grade.

As will be seen by the minutes of the board, this matter was brought to its attention by a report submitted by myself under date of May 12, 1904, at about which time the more serious trouble commenced. This work continued, and a month later, no better results having been obtained, portions of the estimates of amounts due the contractor were withheld by reason of this defective work, and additional amounts have been withheld from month to month up to the present time, amounting in the aggregate to a very considerable sum. This amount has not only been withheld by the city from the contractor, but by the contractor from his sub-contractor, and enough has been kept back from the sub-contractor to compensate for reconstruction when required.

On June 16, 1904, I made a further report to the board:

CAUSE OF THE TROUBLE.

The cause of the trouble was the failure of the sub-contractor to maintain a sufficient air pressure at the shield to keep out the water, and so keep the ground in a proper condition to maintain the weight of the shield. Instead of keeping the pressure high for this purpose, which might have been done by increasing the supply of air, or by the use of special devices or methods to diminish its loss, the excess of water was diminished by rapid pumping. The effect of this pumping was to draw the sand from underneath the shield, the heavy weight of which caused it to settle gradually, even when it was not being advanced. The attention of the superintendent for the sub-contractor was repeatedly called to this matter, and he was urged to make all efforts to keep the shield up to grade, with the idea of avoiding the necessity for future reconstruction, and the contractor was also consulted with. On May 20 I had a conference at the contractor's office, at which Contractor McDonald, Mr. Deyo, the contractor's chief engineer, and the superintendent in charge of the work for the sub-contractor were present. I informed them that the whole difficulty was in not carrying out properly a method correct in principle, and that there was not being maintained a sufficient pressure of air to balance the pressure of water.

After this conference better results were obtained, more particularly under the river.

The endeavor of the contractor was to get the work as much advanced as possible, and the question of the reconstruction of this section of tunnel was postponed until a time when it would not interfere materially with the general progress of the work.

Studies of the conditions showed that, with slight changes in the elevation of the base of rail, ample clearance could be obtained and trains could be satisfactorily run through the tube without necessitating a great deal of reconstruction.

Subsequently, however, the contractor asked for a greater clearance than was at first contemplated, and by reason of this demand for a greater clearance, it was found that it would be necessary to reconstruct a still greater amount of the tube. It also appeared about this time that the superintendent for the sub-contractor had concluded, from his point of view, that it was a practical impossibility to keep to the exact theoretical grade, and he requested the chief engineer of the Rapid Transit Subway Construction Company to give him a limit for deviation from the theoretical grade which would be satisfactory to him. My understanding is that the chief engineer very properly replied informing him that no deviation from these lines would be authorized.

The contractor was ordered to reconstruct on certain lines, which were agreed upon last October. Since that time the contractor and the sub-contractor have been in consultation with reference to the payment for this reconstruction, and this department has endeavored in every way to facilitate the negotiations between the two parties.

COST OF RECONSTRUCTION.

Last February the contractor called in consultation a well-known tunnel engineer, and a report was made suggesting a method that, in my opinion, was ill-advised. The reconstruction, according to his estimate, would involve an expenditure of nearly $1,000,000, and it would take fifteen months to complete the work. Since that time another method has been proposed, and is now in process of execution, by which the work will be accomplished with an expenditure of less than $200,000, will allow for the operation of the tunnel by the first of the year, and also provide for carrying on simultaneously the work of advancing the headings near the middle of the river.

It has been the purpose of the engineering department of the Rapid Transit Board not to interfere in this work in any way which would place upon the city the responsibility of defects in the manner of operating the shield system.

Since early in the work, when the sub-contractor showed a disposition to shift the responsibility for the deviation of the shield from the established line upon the engineering department of the board, especial care has been taken to keep the sub-contractor well informed as to the actual position of the shields, without in any way directing him as to the manner of guidance. While this has resulted in less satisfactory work, it has been consistent with my position of non-interference with methods, and this means of protecting the city's interests was called to the attention of the board at a public meeting when it was fully explained.

This is also a reiteration of my views as expressed to the board in my letter of June 16, 1904, portions of which I consider of enough importance to repeat here:

"It has been the policy of the Engineering Department to keep the contractor, through the superintendent and his assistants, fully advised as to the movement of the tubes and the shields as the work progressed, and the operation of the shields and the general conduct of the work has been left to the contractor, he being held responsible for the work.

"With the exception of a period of one week last November, when special experiments were made in connection with shield jacks at Chief Engineer Parsons's request, this course has been consistently pursued, the contractor being kept fully advised as to the position of the tubes regarding both line and grade. In addition to written instructions, which were given at the request of his superintendent, profiles of the progress of the work and the movement of the shields have been posted in the contractor's office, and when the shields were losing their grade by sinking, the contractor's attention was immediately called to the fact.

"From the early construction of the work the tunnel lining has in some cases been cracked, and such linings have been ordered removed from time to time as defective work, but in most cases their removal has been delayed, with the understanding that they would be replaced later or put in proper condition. Any imperfect work has been from month to month deducted from the estimates."

The contractor, recognizing the fact that this work devolves upon him to finish, is using every endeavor to see that the contract is completed in as short a time as possible.

On March 1 of last year I was so impressed with the fact that valuable time was being lost, that I directed the board's attention to the fact that I had notified the contractor that he was not making sufficient progress to complete his work on time.

At the request of the contractor a conference was had at his office in the latter part of February last, and as the result of that conference the superintendent, who, to my mind, had been responsible for the delay and the defective work, was removed from its supervision, and the board was so notified in my letter of March 21. From that time the work has progressed in a more satisfactory manner, and I am confident that, if no unforeseen obstacle be met in the middle of the river, it will be finished by the first of next year.

EXTENT OF REPAIRS.

The reconstruction as proposed will be for a length of 1,800 ft. in the north tube, and 700 ft. in the south tube.

As there has been a question raised as to the adequacy in the strength of the cast-iron plates used in the tunnel lining, I desire to say that our experience has proven that they are sufficiently strong under normal conditions. Where they have failed or cracked, it has been owing to abnormal strains, due to improper methods employed by the sub-contractor in using the shield. When any changes in thickness have been made by the contractor they have always been approved by myself.

The necessity for correcting the deviations of the tubes where improperly driven, without causing delay to their final completion, has at no time been lost sight of. With this feature in mind, preparations for the work of reconstruction have now been in progress for several months. An experiment is being tried on a small scale with the freezing process which may prove its practicability for this purpose, but in any event the success of the experiment is not depended on. During the past few weeks a portion of the south tube has been rebuilt under the direction of Messrs. Cranford & McNamee, the sub-contractors for the adjoining section in Brooklyn, by an improved method which consists in removing the bottom of the tube and replacing it at the distance required for clearance. This has been accomplished successfully and at much less trouble and expense than was expected.

TO BE IN OPERATION JAN. 1, 1907.

Preparations are being made to install shields in the Manhattan headings, where they pass from rock into earth, by the use of which more rapid progress can be made in the future. If no unforeseen contingencies occur, and none are anticipated of a kind different from those already met and overcome, the river headings should meet next November.

In view of this and the success of the reconstruction work already done, I have no hesitation in predicting the completion of the river tunnels to be ready for operation by the first of the year.

The material which we have encountered in the East River is such that, after the construction of the tunnel, it can absolutely be relied upon to stay in place. This material, while causing a less rapid progress than that which was found in the North River, which has a very large amount of yielding material, can always be depended upon to maintain the tubes in a safe and permanent position.

The city of New York has already constructed two tunnels from Manhattan to the nearest mainland, which are now in complete operation, one built in 1889, conveying the Croton water supply under the Harlem River, and the other, the Rapid Transit Railway tunnel, passing under the Harlem River to the Bronx, built in 1905.

George S. Rice,
May 22, 1906. Chief Engineer.

A BILL AUTHORIZING boating and fishing on certain large reservoirs forming a part of the water supply of Boston and vicinity has been vetoed by Governor Guild. The bill, apparently, took the control of boating out of the hands of the Metropolitan Water & Sewerage Commission. A number of engineers and sanitarians opposed the bill.

A FLOOR-BEAM SCALE IN PARALLEL COORDINATES.

By Lucien E. Picolet.*

The parallel-coördinate beam scale consists of three parallel lines, on which are marked scales of span, spacing and moduli of sections or equivalent sizes of beams required. For a given span and spacing, the required beam size is found by laying a straight edge at the given values of span and spacing and reading the nearest beam size above the straight edge. For example, in Fig. 4 to find the size of beam required for a span of 23.5 ft. and spacing of 7 ft., lay the straight edge so as to pass through the point 23.5 on the l-scale and the point 7 on the d-scale. The straight edge cuts the m-scale at a point marked 31.5, the required beam size (12-in. I-beam, 31.5 lbs. per ft.).

The result can be read at a glance from the diagram. Repeated trials with varying spacing, span, or beam size involve considerably less labor than is required for an equal number of references to tables arranged under each separate size of beam.

In the diagram reproduced as Fig. 4 herewith the scales are arranged for a unit stress of 16,000 lbs. per sq. in. and a uniformly distributed loading of 100 lbs. per sq. ft. of floor.

The principle employed in this diagram has been developed and fully treated by Mr. M. d'Ocagne in his "Nomographie,"† devoted to the analysis of various forms of diagrams for the graphic solution of physical problems. For a detailed exposition of the subject the above treatise should be referred to, but the following simple derivation covers the case in hand.

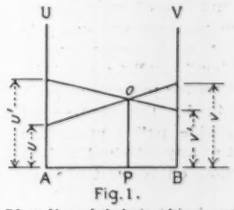


Fig. 1.

In Fig. 1, u and v are quantities laid off to a suitable uniform scale on the parallel lines A U and B V from the base line A B. If a line joining given values of these quantities constantly passes through a fixed point o, they follow, in rectangular coördinates, the straight line law

$$a\,u + b\,v = c \quad \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

If u^1 and v^1 are any other values of the variables, we have also

$$a\,u^1 + b\,v^1 = c \quad \ldots\ldots\ldots\ldots\ldots\ldots (2)$$

From (1) and (2)

$$a\,(u^1 - u) = b\,(v - v^1)$$

and

$$\frac{u^1 - u}{v - v^1} = \frac{b}{a} \quad \ldots\ldots\ldots\ldots (3)$$

From similar triangles $\frac{u^1 - u}{v - v^1} = \frac{PA}{PB}$ and

$$\frac{PA}{PB} = \frac{b}{a} \quad \ldots\ldots\ldots\ldots\ldots (4)$$

From which the position of P may be determined along the arbitrary length A B. Also

$$\frac{v - OP}{OP - u} = \frac{PB}{PA} = \frac{a}{b} \text{ and } \frac{v - u}{OP - u} = \frac{a+b}{b}, \text{ from}$$

which $OP = \frac{b}{a+b}(v - u) + u$ which reduces to

$$OP = \frac{a\,u + b\,v}{a+b} = \frac{c}{a+b} \quad \ldots\ldots\ldots\ldots (5)$$

In rectangular coördinates different values of c in (1) are represented by a series of parallel lines, while in parallel coördinates the change in this term merely changes the position of the point o along O P, the points on U and V remaining unchanged.

With a floor load of 100 lbs. per sq. ft. and a unit stress of 16,000 lbs. per sq. in., the relation-

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*2217 North 52d St., Philadelphia, Pa.

†Traité de Nomographie, by Maurice d'Ocagne, Paris, Gauthier-Villars.

ship between spacing, span and section modulus of the beam required is,

$$s\,l^2 = 106.66\ m \quad \ldots\ldots(6)$$

where d and m are respectively, the spacing, span and section modulus. Written logarithmically, this becomes the equation of a straight line, similar to (1),

$$\log d + 2 \log l = \log 106.66 + \log m \quad \ldots\ldots(7)$$

Thus, $d = u$; $\log l = v$; $\log 106.66 + \log m = c$; and $2 = b$.

To construct the diagram, the logarithms of the quantities in Eq. (7) are laid off to scale from the points A, B and P, as shown in the sketch, Fig. 2. It may be mentioned that the logarithmic values need not be taken from a table, as they can be traced directly from the scale of an ordinary slide-rule, the smaller scale being most suitable for a diagram of convenient size. The values of d and l are traced directly from the scale, beginning at the points A and B, these points coinciding with unity on the rule.

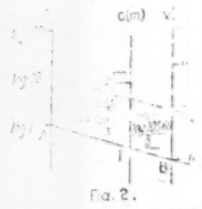


Fig. 2.

The scale of c passes through the point P determined by the ratio

$$\frac{A\,P}{B\,P} = \frac{b}{a} = \frac{2}{1}$$

From Eqs. (5) and (7),

$$\frac{O\,P = c}{a+b} = \frac{\log 106.66 + \log m}{3}$$

The scale on this line is, therefore, only one-third the length of that employed for the other two, and the starting point (unity) is not at the point P, but at log 106.66, above it. It is a simple matter to derive this scale by proportional lines from the d-scale to a point on the l-scale, as the ratio of the two scales is identical with that between A B and P B. This construction is shown by the broken lines.

In constructing the final diagram, Eq. (7) has been transformed in order that the m-scale may be larger, as follows:

$$\log m - \log d = 2 \log l - \log 106.66 \quad \ldots\ldots(8)$$

which gives $u = \log m$; $v = -\log d$; $a = 1$; $b = 1$;

$$\frac{c}{a+b} = \frac{2 \log l - \log 106.66}{2} = \log l - \frac{\log 106.66}{2}$$

and

$$\frac{A\,P}{B\,P} = \frac{a}{b} = 1.$$

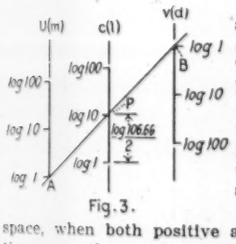


Fig. 3.

The scales are all alike and arranged as shown in Fig. 3. The m-scale being large, the section size corresponding to a given modulus may be written upon it without serious crowding.

To economize space, when both positive and negative quantities occur, the point P may be raised, and with it the point B, without changing the geometrical relationship, as has been done in Fig. 3. With the line A B horizontal, the diagram would take double the space of the former arrangement.

In the working diagram, Fig. 4, the scales shown in Fig. 3 are interchanged, the m-scale being placed on the right. It is evident that the readings are in no way altered thereby.

Other unit stresses and loads than those upon which the diagram is based may be introduced in the solution of problems by the use of the auxiliary points marked on the inside of the d and m scales. The process of modifying the direct readings of the scale is best described by a concrete example.

Let the floor load be 150 lbs. per sq. ft. in the example given above. Join c on the m-scale with 100 on the auxiliary d-scale by a straight line intersecting the l-scale at e. Through e and 150 on the d-scale draw another line, cutting the m-scale at f; this point lies between the points 15-42 and 12-40, indicating that a 15-in. I, 42 lbs. per ft., is required.

If a unit stress of 12,500 lbs. is required instead of 16,000 lbs., draw a line from c to 16,000 on the auxiliary d-scale, cutting the l-scale at g. A line joining g and 12,500 falls between 12-40 and 15-42 on the m-scale; the latter is the beam required for this stress. A line from the 15-42 point through g cuts the d-scale somewhere below the 10,000 point, indicating that the unit stress sought cannot be realized with the given span and spacing.

With a unit stress of 16,000, the limiting deflection of $^1/_{360}$ span is not exceeded when the depth of the beam in inches is not less than one-half span in feet. In the case given, the depth of beam is 12 ins. and the span in feet divided by 2 is 11.75, nearly at the limiting point. For other unit stresses, the figures in the m-scale are used, and the results in inches read from the l scale. For example: To determine the minimum allowable depth of beam with a stress of 12,500 lbs. per sq. in., draw a line through b and x, on the m-scale, cutting the d-scale at h, a line through h and the 12,500 point on the m-scale cuts the l-scale between 9 and 10, showing that the least allowable depth of beam in inches falls between these values.

These modifications of the direct readings can also be made by making the center scale vertically movable opposite gage points, expressing the ratio of unit stress and unit floor load.

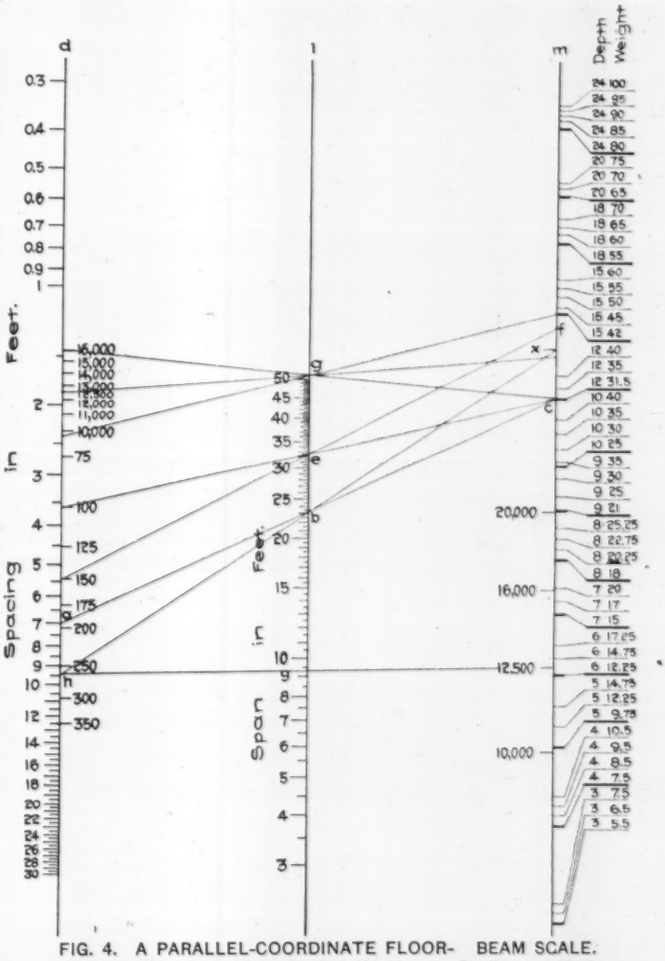


FIG. 4. A PARALLEL-COORDINATE FLOOR- BEAM SCALE.
For Uniformly-Distributed Floor Load of 100 Lbs. per Sq. Ft., and Maximum Fiber Stress of 16,000 Lbs. per Sq. In.
Auxiliary Scales for Other Loadings and Stresses.

A NEW CONDUIT FOR UNDERGROUND PIPES.

A new style of conduit for underground steam and hot water pipes is now being placed extensively upon the market. Having been in restricted use, especially in the Eastern States, for the last seven years it has been found to give such satisfactory results that it is now proposed to push its sale throughout the country.

The Portland sectional conduit is a glazed tile pipe made in top and bottom sections. These tiles are made in 3-ft. lengths, being brought to a sectional form by cutting half through the shell of the pipe before it is baked and breaking it longitudinally after removal from the kiln. This leaves the shell with a rough serrated edge without glaze, which will give a water tight joint when properly put together with Portland cement. This method of sectionalizing the tile prevents warping and guarantees tight joints, the top and bottom sections being numbered with corresponding numbers to prevent mismating.

One of the most important features of the Portland sectional conduit is the supporting tee, which partakes of the nature of a 90° branch tee of

SECTIONS OF A PORTLAND SECTIONAL CONDUIT SYSTEM.

The price of this conduit is higher than the price of wooden conduits, but when it is considered that more than one pipe line can be run in the same conduit and a higher efficiency obtained by its use, together with the fact that it is practically imperishable, the balance is in its favor.

sewer pipe—but which is split on the diametrical plane perpendicular to the axis of the branch. In laying the conduit the half of the tee containing the branch is placed at the right elevation with branch down, and the branch filled

with concrete, after the wrought iron roll frame for carrying the pipes has been placed in position. This construction provides for the carrying of the pipes upon a concrete foundation and prevents any of the weight coming upon the conduit. These tees are placed from 12 to 18 ft. on centers, according to the size of pipes to be carried.

The roll frames are ordinarily made to carry from one to four pipes, but are also made, to order, to support any combination of pipes that may be contained in the conduit. These frames carry rolls on which the pipes rest, so that in expanding and contracting the pipes simply slide in the conduit without displacing it. This arrangement, therefore, does away with a large number of expansion joints, since the ease with which the pipes move permits one joint to compensate for long lengths of pipes.

In installing this conduit the lower halves of the conduit are laid upon a 6-in. bed of gravel or broken stone placed in the bottom of the trench and leveled off to the proper grade. After the sections are properly placed and cemented with Portland cement, the filling of gravel or stone is carried up around the conduit, nearly to the level of the side joints. When the concrete in the support tees has set, the pipes are placed on the rolls and properly connected. These pipes should then be thoroughly blown out to remove all scale and dirt, and then tested at a pressure at least 50% in excess of the working pressure. If there are no leaks the top sections of the conduit are cemented into place, one at a time, and the space around the pipes filled with asbestos-sponge conduit filling, other insulations can be used, but are not recommended. After the cemented joints of the conduit have hardened the stone or gravel filling is carried at least 6 ins. above the side joints, and the trench is then filled with earth tamped solid.

If it should become necessary to repair the pipe line at any point, it is only necessary to remove the other half of conduit, which can be done with a chisel without injury to the tile, and, after completing the repair, the removed tile can be replaced and cemented into place.

The advantages claimed for this conduit over existing styles are: ease of installation, high insulating properties, imperishability, ease of repairs, and ability to carry more than one pipe in the same conduit.

Following is a summation of the results of a test made upon a 600-ft. conduit line at Phillips Academy, Andover, Mass., by Mr. Geo. H. Barrus, Expert and Consulting Engineer, Boston, Mass.:

Briefly reviewing the results, it appears that the rate of condensation per square foot of outside surface of the iron pipe per hour was 0.0989 lbs. on the high pressure test (83 lbs.); and 0.0455 lbs. on the low pressure test (6 lbs.); and the loss of heat from the pipe covered, expressed in heat units per degree difference in temperature between the steam within and an assumed temperature of 70 degrees without, per square foot of outside surface per hour, was 0.349 B. T. U. on the high pressure test and 0.273 B. T. U. on the low pressure test. Compared with the loss from a bare pipe, in still air, these results show efficiencies of 88.7% and 87%, respectively.

The efficiency results obtained from the underground pipe are superior to those obtained from pipes exposed to the air at the same pressures and temperatures, using the best coverings ordinarily sold by the trade, in thicknesses of from 1" to 1¾".

The accompanying cut shows the manner of installing this conduit, which is manufactured in nine sizes from 8 to 30 ins. diameter by the H. W. Johns-Manville Co., 100 William St., New York City.

ANNUAL CONVENTION OF THE NATIONAL FIRE PROTECTION ASSOCIATION.

The tenth annual meeting of this association was held at the Auditorium Hotel, Chicago, May 22 to 24, with a large attendance. The report of the secretary showed a total membership of 1,002, including 50 insurance and technical societies and 952 personal members. In addition to five business sessions there was one evening session at which Mr. John B. Laidlaw delivered a lecture on "The Conflagration Hazard" illustrated by numerous lantern slides of maps and views of noted fires from the great fire of London, in 1666, to the recent San Francisco fire. A visit was also paid to the Underwriters' Laboratory, to inspect the building and its equipment, and to see the character of the work and tests now being carried out. An address in commemoration of the tenth anniversary of the association was delivered by Mr. U. C. Crosby, past president, and a description of the efficiency of the fireproofing and fire protection equipment of the San Francisco plant of the Western Electric Co. was also given. The rest of the proceedings consisted in the presentation and discussion of committee reports. The officers of the association were reelected, as follows: President, C. A. Hexamer; Vice-President, Wm. A. Anderson; Secretary and Treasurer, W. H. Merrill, Jr.

About 20 committee reports were taken up, and notes of these are presented herewith, the reports being for convenience grouped according to their subject matter:

BUILDING CONSTRUCTION.

CEMENT FOR BUILDING CONSTRUCTION.—This report dealt with concrete rather than cement, and was printed practically in full on p. 588 of our last issue.

THEATER CONSTRUCTION AND EQUIPMENT.—This report consisted mainly of that section of the building code of the National Board of Fire Underwriters which relates to theater construction and equipment, but with certain amendments and additions. The additions included specifications for steel and asbestos theater curtains, and the committee was of opinion that steel curtains similar to those now required in Chicago should be the standard of the association, relegating the asbestos curtain to a secondary place. The report was not read or discussed, but the chairman of the committee (and president of the association), Mr. C. A. Hexamer, explained its purpose and asked its adoption. It was adopted by a unanimous vote.

CAR HOUSES.—This report presented requirements as to the construction and fire-protection equipment of railway car storage houses. No specific requirements as to concrete construction were included, however, and this led to some criticism, but this was met by calling attention to the following extract from the general portion of the report. The committee on Fireproof Construction, which is considering the matter of the use of concrete, had no report:

> Railway companies generally are giving closer attention than formerly to the importance attached to erecting car houses of non-combustible, and slow-burning construction; also to the limitation of car values in any one fire division. Noticeable among the properties erected of late, are several of reinforced concrete type throughout, and others of brick walls and reinforced concrete and tile roof construction. This type of construction seems to permit of the practice of eliminating interior columns, the width of building being such as to accommodate not more than three parallel tracks, with roof girders having as support the side walls only, the span not exceeding, say 35 ft. Your committee respectfully requests that this Association adopt a standard for reinforced concrete construction for buildings. This class of construction is in general use in many cities, and a guide as to what may constitute proper construction is greatly needed.

The use of the sprinkler system was recommended, and the committee is considering the question of the application of this system to car storage yards, for although in most cases the storage of cars in the open is not considered advisable, in some cases railways use and favor this practice. The use of non-combustible and semi-non-combustible cars is not likely to be generally adopted by street railways for some time, but a car house of standard non-combustible construction would require less expenditure for sprinkler equipment, and would also eliminate any building exposure to the cars.

FACTORY STANDARDS.—This report presented the standards of requirements drawn up by special sub-committees for four classes of factories: cotton-seed oil mills, rice mills, fertilizer factories and breweries. These included construction, power, heating and lighting and fire protection, but as they had not been passed upon by the main committee, it was considered advisable to refer them back to that committee before undertaking to discuss them.

WINDOW AND DOOR OPENINGS.—The committee on fire-protecting coverings for window and door openings presented a number of changes in the present standards relating to fire doors and shutters, and reported that in many localities the protection of wall openings is seriously neglected. In the laboratory work, several substitutes for the wood-filled tin-clad door are being developed. The specifications were discussed at considerable length in regard to matters of detail.

SKYLIGHTS.—This report related to the arrangement, construction and protection of all kinds of skylights, and all other roof openings for buildings of different kinds.

CHIMNEYS AND FLUES.—The report covered boiler, furnace and oven flues, etc., as well as heating flues, stove pipes, etc., in residences. The committee expressed the opinion that there are hundreds of thousands of existing buildings having defective chimneys and flues, so that the matter of safety and protection to the greatest extent lies in the hands of the inspection bureaus and inspectors.

WATER SUPPLY.

PUMPS.—From the brief report of this committee we take the following extracts:

Steam Pumps: The general experience with the Underwriter pump for the year has been satisfactory. A number of pump shops were visited during the year and with slight exception it was found that manufacturers were adhering closely to the specifications and building thoroughly good and reliable machines.

Rotary Pumps: The manufacturers of rotary pumps have generally made such modifications in their designs as to bring the pumps into conformity with the specifications adopted at our last meeting. A special type of stuffing box was got up in order to permit a very compact arrangement and a short distance between main bearings. As this is a somewhat special design, it is desirable that manufacturers use their own best ingenuity in working out the details, and it is also recommended that they submit drawings showing how they have worked out the problem. In this way the committee will be enabled to criticize and suggest from their experience in other directions. In fact, as with the steam pump, there is much to be gained by submitting a full set of drawings before any new type of rotary pump is built, thus getting the experience of underwriters from their constant testing of these pumps, and often making possible improvements which would be much more expensive to adopt after patterns were completed.

Centrifugal Pumps: The progress of centrifugal pump building has been watched with interest during the year and the prospect is good that pumps of this type will prove reliable and satisfactory for fire purposes. Such pumps run with great smoothness, and as their normal speed can easily be that of an electric motor, it makes a simple and good arrangement.

Power Pumps: The question occasionally arises as to the use of power pumps, generally the ordinary triplex pump, for fire purposes. There would seem no reason why a pump of this type could not be built in so substantial a manner as to be a reliable fire pump. The probable use of these pumps for fire purposes, considering that they are high in price, seems so small that there is no need of making specifications for them.

Nothing of special importance has developed during the year in regard to steam pump regulators and auxiliary pumps or in regard to electrically driven pumps.

VALVES.—This committee's report consisted simply of specifications for gate and check valves for fire protection use, the aim being to require valves which are strong and reliable and as far as possible agreeing with present shop practice.

SMALL RESERVOIRS AND VALVE PITS.—The committee is of opinion that reinforced concrete is the best material for the construction of reservoirs, and that they should preferably be circular in form, rectangular tanks costing about 25% more than circular tanks of the same capacity. A uniform depth of 10 ft. is suggested, with walls 6 ins. thick at the top and 8 ins. at the bottom; the floor to be 6 ins. thick if on solid foundation, or 12 ins. if on piles. The diameter would be from 23 ft. for 30,000 gallons capacity to 64 ft. for 240,000 gallons. The report was accompanied by specifications and plans for both reservoirs and valve pits. It was extensively discussed, with the result that numerous changes will be made in the specifications.

PRIVATE FIRE SUPPLIES FROM PUBLIC MAINS.—This report was brief but dealt with two important points, and we give an extract from it as follows:

The relations which have existed between water department and insurance men have been satisfactory, showing again the benefit of the cooperation which has been [illegible] inaugurated.

The [illegible]ey Mfg. Co., Boston, Mass., reports that it has [illegible]bout 50 of the detector devices which were described [illegible] our report of last year. These, they state,

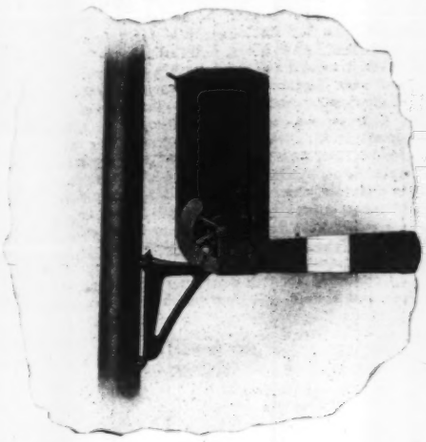


Fig. 1. Telephone Train-Order Signal for Electric Railways.

have given universal satisfaction, and those which have come under our own observation have done the work for which they are intended in an acceptable manner. The meter designed by the inspection department of the Associated Factory Mutual Fire Insurance Companies was further perfected and a complete description of it was presented to the New England Water-Works Association at the annual convention in September. The fact that photographs and actual results from a meter already built could be shown gave the water-works men positive information that we were earnestly studying this prob'em, and this has proved a valuable means of showing our strong intention to work together on this problem until a thoroughly satisfactory solution to water-works officials, underwriters and owners is reached. Following the water-works meeting a few details were perfected and a number of 6-in. meters are now being built which it is expected will be put into service during the coming summer. Designs have also been blocked out for larger sizes, which as soon as possible will be built.

The experience of the year has further shown the desirability of encouraging in nearly all places the separation of piping used to carry water for manufacturing purposes from the fire system. Such separation not only makes the metering problem easier, but is much better from the fire standpoint. Where the mill supply is drawn from the fire pipes, and where considerable quantities of water are used the result is likely to be when a fire starts that a considerable percentage of the capacity of the fire pump will be wasted through the ordinary mill connections, especially in cases where the fire pump pressure would be considerably higher than the normal public water pressure, so that as soon as the fire pump started it would close the check valves in the public connections, thus putting the whole duty on to the fire pump.

STANDARD HOSE COUPLINGS AND HYDRANT FITTINGS.—The report of the special committee on standard hose couplings and hydrant fittings for public fire service reviewed the work of the committee and the degree of success so far attained. One of the most important results was the adoption of this association's standard coupling by the New England Water-Works Association, the International Association of Fire Engineers and the National Firemen's Association at their annual meetings in 1905. It has also been endorsed by the American Water-Works Association and the National Board of Fire Underwriters. The general feature is the adoption of 7½ threads per inch and $3^{1}/_{16}$ ins. outside diameter for coupling of 2½-in. hose. The committee also took up the subject of standardization of the operating nuts on hydrants, and reported that replies to its enquiries showed over 90% in favor of a pentagon nut 1½ ins. from flat to point, and the same proportion in favor of turning the stem to the left in opening the hydrant. As an illustration of the importance of uniformity in couplings it was pointed out that the adjacent cities of St. Paul and Minneapolis have couplings of different diameters, so that in case of a serious fire the engines of one city could not help those of the other except by the use of "adapters" in coupling to the hydrants. The committee pointed out very forcibly that the adoption of the standard is only a beginning, and much has now to be done to ensure the acceptance and use of the standard throughout the country.

SPRINKLERS FOR FIRE PROTECTION.—The committee on Special Hazards and Fire Record reported that 894 fires in places having

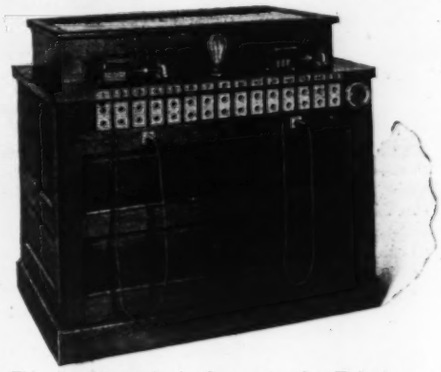


Fig. 2. Dispatcher's Apparatus for Telephone Train-Order Signal.
The Blake Signal & Mfg. Co., Boston, Mass., Makers.

sprinkler equipment were reported last year; 731 of these were either extinguished or held in check to allow of extinguishment by such outside aid as was at hand. In 114 fires the heat was insufficient to operate the sprinklers, while in only 49 cases the sprinklers were unsuccessful. As to the general efficiency of the sprinkler system we quote the report as follows:

As regards the 49 unsatisfactory cases, the following features are particularly interesting. In eight fires or one-sixth of the whole, water was shut off due to freezing, or water supply crippled from the same reason, showing what an important effect cold weather has on the sprinkler fire loss, and in connection with this should also be noted three unsatisfactory fires due to inoperative or defective dry valves. High test heads failed to operate properly in three cases, thus giving practical examples of the dangers attendant upon the promiscuous use of high test heads. Obstructions to distribution account for an unusually large number of unsatisfactory cases, five in all, over 10%. Defective or obsolete and partial equipments together with light water pressure or defective supplies account for about one-third of the failures, and water shut off or crippled by freezing another one-third.

Of more interest than anything else perhaps is the fact that practically all of these troubles are remedial, in that given a standard sprinkler equipment, a good building, ordinary occupancy and proper maintenance of the system, and the chance of a loss is practically eliminated, so far as internal fires are concerned. This should encourage the fire protection engineer and gradually bring about the necessary improvements, thereby reducing the fire loss to the minimum on this class of risk.

MISCELLANEOUS.

The committee on Devices and Materials submitted revised specifications for carbonic-acid gas hand fire extinguishers for other than fire department use; for the chemical charge it recommended 1¼ to 1½ lbs. of bicarbonate of soda and 3½ to 4 fluid ounces of sulphuric acid, the proportions being such that a pressure of 325 lbs. cannot be exceeded. The capacity of the tank to be about 3 gallons. A committee on Non-Freezing Compounds for Fire Extinguishers reported that the ordinary charge in a chemical extinguisher will probably freeze at about 20° F. Several chemical compounds were mentioned, but none of these meet all the requirements. The committee, considered, however, that a suitable compound could be developed by careful investigation, and pointed out that the retardation of chemical action at low temperatures is a matter calling for serious consideration. Watchmen and watchmen's lanterns, matches and lightning protection were among the other subjects dealt with in the reports, the last including detailed suggestions for the protection of buildings against lightning. In view of the numerous changes advocated during the discussion this report was referred to the executive committee.

A TRAIN ORDER SIGNAL SYSTEM FOR ELECTRIC RAILWAYS.

With the increase in length of electric interurban railways and the increase in speed and traffic, systematic methods of controlling the movements of cars become necessary, and such methods are being introduced on several roads of this class. Probably a majority of these interurban lines are operated on the train-dispatcher system, with telephone instead of telegraph communication. The crews report by telephone at stations, passing sidings, etc., while

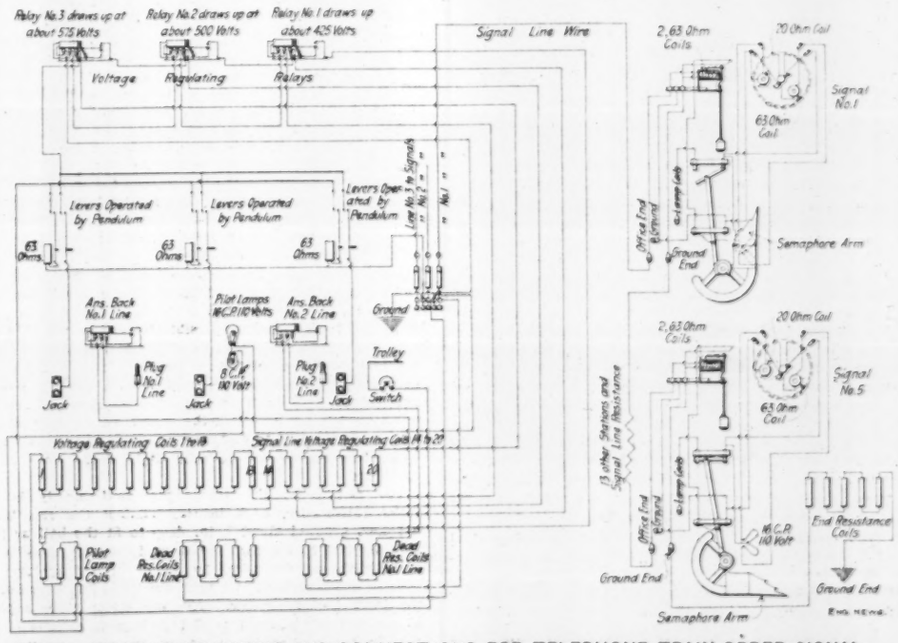

Relay No. 3 draws up at about 575 Volts
Relay No. 2 draws up at about 500 Volts
Relay No. 1 draws up about 425 Volts
Signal Line Wire
Voltage Regulating Relays
Levers Operated by Pendulum
Levers Operated by Pendulum
Levers Operated by Pendulum
63 Ohms
Arm, Back No. 1 Line
Pilot Lamps 16 C.P. 110 Volts
Arm, Back No. 2 Line
Ground
Trolley
Plug No. 1 Line
Plug No. 2 Line
Jack
Switch
Voltage Regulating Coils 1 to 19
Signal Line Voltage Regulating Coils 19 to 20
Pilot Lamp Coils
Dead Res. Coils No. 1 Line
Dead Res. Coils No. 1 Line
2, 63 Ohm Coils
20 Ohm Coil
63 Ohm Coil
Signal No. 1
Office End
Ground End
Semaphore Arm
Signal No. 5
(3 other Stations and Signal Line Resistance
16 C.P. 110 Volt
End Resistance Coils
Ground End
Semaphore Arm

FIG. 3. DIAGRAM OF WIRING AND CONNECTIONS FOR TELEPHONE TRAIN-ORDER SIGNAL.

connections on the poles at frequent intervals allow of special communication in case of emergency. In this system the men call the dispatcher, but the latter has ordinarily no means of calling the attention of the men on the car in the event of any special orders being required. In the Blake signal system, however, semaphore and lamp signals are placed along the line and

are under the control of the dispatcher. It is to be noted that they are not block signals or automatic signals, but are simply train-order signals to indicate when cars are to be stopped for orders. In this respect they are similar to the train-order signals on steam railways, but while in the latter case the dispatcher communicates with an operator, on the electric railway he operates the signals directly. Fig. 1 shows the signal attached to a trolley pole, and Fig. 2 is a view of the apparatus in the dispatcher's office. Fig. 3 is a diagram of the wiring and apparatus. The following description is taken from a paper read at the March meeting of the Central Electric Railway Association by Mr. E. J. Burke, of the company that makes this type of signal:

The apparatus consists of dispatcher's office equipment and line semaphore signals, each signal containing an electromagnet and pendulum. These signal pendulums vary in length, and each one corresponds in length to one of the pendulums in the dispatcher's office. The dispatcher's office equipment consists of a desk or cabinet box containing 15 pendulums of different lengths and platinum contacts, which are made and broken by the swing of the pendulums at intervals varying with the length of the pendulums; they are capable of transmitting impulses over the line (consisting of a single, bare, iron wire), which impulses are synchronous with that dispatcher's office pendulum which happens to be vibrating, and influence only that signal on the line which the dispatcher desires to operate.

The basic principle of the signals is that the time of vibration of a pendulum varies with its length. Therefore, if we, at some central point, such as a dispatcher's office, start in vibration a pendulum of a certain length, allowing it, as it vibrates, to open and close an electric circuit, electric impulses will be set up in that circuit, synchronous with the vibrating pendulum. These impulses energize the electromagnets of all the signals on the circuit, and start vibrations in all of the signal pendulums. On only one signal, however, namely, that one whose pendulum is of the same length and therefore synchronous with the pendulum vibrating in the dispatcher's office, will these electromagnetic impulses be of a proper period to be cumulative in effect, and swing the pendulum in an ever increasing arc of vibration. On all the other signals, the impulses being out of beat, the pendulums will receive a check before they have swung through any considerable arc.

On the signal which it is desired to set and on the pendulum of which these synchronous impulses are accumulating energy, the pendulum having reached a certain arc of vibration, mechanically trips a lock, releasing a 3-ft. semaphore arm which falls to the horizontal position by gravity. Having reached a horizontal position, this semaphore closes the local signal lamp circuit and also interruptedly closes a shunt to ground on the signal line, causing a sounder to draw up in the dispatcher's office and notify him of the fact that the signal has operated.

For instance, when the dispatcher wishes to set signal No. 9 he inserts a plug, similar to a telephone plug, in hole No. 9. This releases pendulum No. 9, and also connects the line with the 500-volt circuit which is brought to the dispatcher's desk. As the pendulum swings it opens and closes the signal line circuit, sending impulses over the line synchronous with its vibration. At the end of 13 seconds this line signal pendulum swings through an arc wide enough to trip a lock and drop the semaphore arm. The car arrives at the station, and the motorman or conductor calls the dispatcher by telephone, saying, "Brown and Hayes at No. 9 for orders." The dispatcher then transmits his orders to the conductor or motorman, who, if so instructed by the dispatcher, then pulls a cord which sets the semaphore at the vertical or "clear" position ready for future operation.

If the dispatcher must give orders for crews to pass at an unusual point, he can, by setting a semaphore and showing a red light, ensure against the crews forgetting to stop at that point. Furthermore, many accidents would undoubtedly be avoided by a dispatcher being able to set a signal and stop or give caution orders to a car crew by telephone at any point on the line.

The mechanism of the signal is entirely independent of the telephone, and where telephones are already installed, the signal may be put up as an adjunct. The following special features may be noted in regard to this signal system:

1. It is physically impossible for any other signal than the one desired to operate.

2. There is a positive indication to the dispatcher, showing that the semaphore arm has been set in the horizontal position; and until the arm has reached an angle of about 45° it is a physical impossibility for the dispatcher to get this indication so that the danger of a false indication is eliminated.

3. The power for operating the signal is obtained entirely through the dispatcher's office, and there is no local circuit at each signal, other than the signal lamp circuit.

4. There are no electrical contacts in series with the operating magnets at the various signals. The signal line is electrically continuous throughout, from the dispatcher's office to the return circuit at the end of the line.

5. If one signal lamp burns out, a second lamp is automatically cut in circuit. This second lamp is in an interrupted circuit and gives a flashing light, so that any crew can report same and a new lamp can be put in the following day. This detail removes the necessity of having a daily inspection of all lamps, as well as the danger from a new lamp being defective and burning out a short while after it has been put in.

6. The widely varying voltage of trolley lines is taken care of by relays which draw up at different voltages, and cut in or cut out resistance as the voltage which is supplied at the dispatcher's office rises or falls. It is able to take care of voltage variations between 300 and 700 volts.

The signal system above described has been in use on the Boston & Worcester Ry., 22 miles, since August, 1903; the Central Illinois Traction Co., 35 miles, since July, 1905, and the Danville, Urbana & Champaign Ry., 40 miles, since January, 1906. It is now being installed on the St. Louis & Springfield Ry. for about 60 miles, and the company has additional contracts as follows: Indiana Union Traction Co., 55 miles between Indianapolis and Muncie, Ind.; East St. Louis and Suburban Ry., 20 miles; and the Chautauqua Traction Co., Jamestown, N. Y., 20 miles. This system is the invention of Mr. C. C. Blake, and is manufactured by the Blake Signal & Mfg. Co., of Boston, Mass.

CURVING RAILS BY POWER: NASHVILLE, CHATTANOOGA & ST. LOUIS RY.*

By Geo. F. Blackie.†

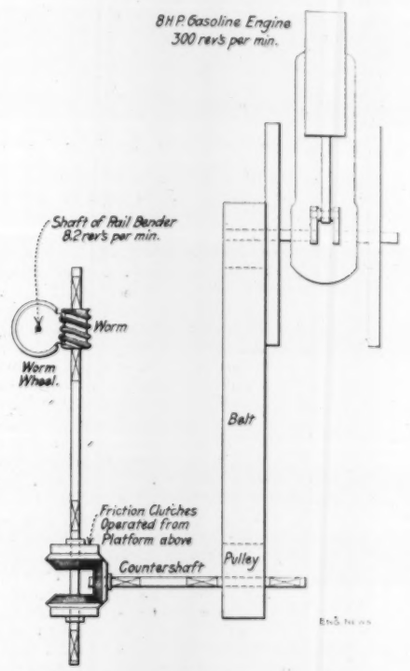
It is impracticable, even with the best form of roadbed, to obtain and maintain a true line on the sharper curves unless the rails have been given the proper "set" with one of the many devices designed for this purpose. Those laid in the track straight and thrown over with bars to fit the curve retain a certain amount of spring, and, even without the effect of the moving train, tend to straighten themselves. It is an unnecessary expense and delay to curve rails weighing less than 60 lbs. per yd.; the paper refers only to 80-lb. rails.

As to what the limiting minimum degree of curvature should be for which rails are to be treated, there is considerable difference of opinion. A number of experienced track men vary in their recommendations from 1° to 4° curves. The deflection per rail length in the curves of long radii is so slight that the rails line well with bars, and the tendency to straighten is overcome by weight of track, etc. The economical point to discontinue treatment is evidently with the curve, laid with straight rails, which is found by experience to retain its good line with only the usual attention from the track men. Any continual extra attentions will soon more than balance the cost of previous curving. It was formerly the practice to bend for 3° curves; but in the last considerable lot of track relaying this was not done, and from the result of the behavior of these rails it appears that some little curvature at least should be given those for 3° curves. Care must be taken not to curve rails to a less radius than that portion of the track for which they are intended; for they are then difficult to get back in good line, and it is almost impossible to avoid tucked joints. For this reason, and on account of the difficulty in curving rails to the exact figured amount, it is best practice to allow them to go to the track with a slightly greater radius. A 33-ft. rail curved to a middle ordinate as much as 3-16-in. less than the calculated middle ordinate for curves from 3° to 4½°, and as much as ¾-in. or even ½-in. less for curves of over 4½°, works very satisfactorily.

The rail-bender the writer has used mostly is the roller rail-bender, each bearing against the rail being a roller, grooved about ⅞-in. deep to fit the ball or rail. It is applied to the rail and is made to roll along it by turning the middle roller by means of a long lever at the top of a vertical standard connected by a socket to the journal of the roller. This operation leaves a piece of straight rail about 1 ft. 3 ins. long at each end, but this is not noticeable except on curves of very short radii. No precautions have been taken against this except in curving rails for rim bearings for turntables. In those cases continuation of the curve to the ends of rails has been accomplished by a screw press.

Instead of having the bender travel over the rail, it is more expedient, under ordinary conditions, along the track, to have the bender stationary the rail travel. The bender is made fast to floor, say 4 × 4 ft. Two or more timber bu rollers up, are placed on each side of the be path of the rail and at an elevation which w base of the rail a bearing on them while goi the bender. In distributing rails for relay points are chosen on or near the curve whe or cut is wide enough to operate the bend of the truck. Sufficient rails for this curve there, and, after being put through the bend tributed around the curve with a push car. If are near together, one setting of the bend economically used for two or more curves.

A force which successfully operates a b consists of a foreman, a wrench man to bender, and two relays of eight men each to nate turns at the lever, the entire force ha to and from the bender. This force should av 50 rails curved per day, at an average cos per rail. To this must be added the cost of by push car after curving. This is necessarily quantity on account of interference by trains, estimated at about 8 cts. per rail, making th per rail curved and distributed from the be



Mechanism for Driving Rail Bender by Power.

The length of time consumed, causing frequent delays to the tracklaying gang, and the excessive cost of bending a large number of rails by hand, led the management of the Nashville, Chattanooga & St. Louis Ry. to look for a more expeditious method. The following is a description of the plant put in operation by this company at Chattanooga, Tenn., during September, 1905.

The roller-bender is used without the vertical standard and lever. It is mounted on a platform level with the top of a flat car, and rollers of 2½-in. iron are sunk into the platform floor at intervals of 10 ft. on either side of the bender and in the path of the rail passing through it. The center roller of the bender is made somewhat larger in diameter than the one used in hand bending, and the journal is replaced by a shaft extended downward. Angle iron boxes bolted to the floor of the platform support the center screw and guide. The holes receiving these parts do not extend entirely through the angle irons, thereby holding the center shaft of the bender firmly in all directions, and the rolls are kept at the proper height to cause the grooves in them to engage the ball of the rail when the base is resting on rollers in the platform. The frame of the bender is free to slide in and out on the center screw and guide to receive the rail to be curved. A block bolted to the platform at each of the end rollers assists in holding the bender rigid when in working position.

The bender receives motion as follows (see the accompanying cut): Under the platform is an 8-HP. gasoline engine, making 300 revolutions per minute. The engine pulley is 16 ins. diameter, and drives a 19-in. pulley on the main shaft at 252.6 revolutions per minute. The main shaft terminates in a miter pinion with 17 teeth, engaging one or the other of two miter gears with 25 teeth each on a countershaft, changing direction horizontally and at right angles. The speed of the counter-

*Abstract of a paper read before the Engineering Association of the South.

†Assistant Engineer, Nashville, Chattanooga & St. Louis Ry., Nashville, Tenn.

shaft is [illegible] revolutions per minute. A worm is on this countershaft and engages a worm wheel on the shaft of the roller in the bender. The ratio of the worm to the worm wheel is 21 to 1, causing the center roller to revolve 8 times per minute. This will take a 33-ft. rail through the bender in about 2½ minutes. The size of parts and speed reduction could be figured out on a more economical basis for the transmission of power; but this outfit was built as an experiment from articles which were, for the most part, on hand at the company's shop, and answered the purpose very well. The bender is in the center of a platform 12 × 100 ft., with a track on each side. Straight rails are received on one side and curved rails are forwarded from the other. Two overhead tracks are erected over the platform and a track, 15 ft. from each side of the bender, and by means of differential pulley blocks and double rail tongs, rails are transferred from car to bender, and to the car. The gasoline and cooling tanks, etc., and all machinery except the bender, are located under the platform. Besides being a protection from weather without the expense of an extra engine house, it admits of the plant being installed where space is rather limited. The cost of this outfit erected was $880, not including tracks, as existing yard tracks were used.

The foreman in charge of the bender is furnished with a list of curves, showing the required middle ordinate of each, the location of the curve with reference to telegraph poles, the number of rails on each curve, also the required number of short lengths for inside to keep the joints properly staggered. He is also given the direction of the curve, so he can notify the yardmen to turn the car when necessary; but if the "Y" or turntable is not convenient, he turns the rails end for end while in the hoist just before loading. The foreman attends to the shipment of cars and notifies all parties concerned in the shipment. As the rails are received from the rolling mills, a sufficient number for curves are sent direct to the bender, and the contents of the cars are checked by the foreman as unloaded.

It frequently occurs, on account of the inaccurate adjustment of the center roller or on account of the difference of one rail from another in temper, that a rail may be curved too much or not enough. If not enough, it is run back through the bender on reversing the machine by means of levers operating the friction-clutch miter gears on the counter shaft. These levers are interlocked so both gears cannot be thrown in at the same time. If the rail is curved too much, it is picked up and dropped sidewise on the floor of the platform. With proper care and judgment, this dropping process will not kink the rail, but will flatten its curvature somewhat throughout its length. It is then run again through the bender. If it is not straightened sufficiently by dropping on the floor, it is turned end for end and straightened by going through the bender.

As stated above, one difficulty in obtaining the desired curve by first trial is on account of the difference of one rail from another in temper. The same set of the center screw of the bender will not curve all rails alike. It sometimes varies very widely. The same set that curves one rail to 1-in. middle ordinate will sometimes make hardly any impression on another rail. The harder rail will spring back on leaving the rolls. This trouble is obviated to quite an extent by noting the heat numbers of the rails and treating those with the same heat number similarly.

This plant can be operated by six men and a foreman, the foreman also looking after the engine and machinery; but on account of the rail (as is so often the case) being delivered in high-side coal cars, and on account of other incidentals, it is economical to use two additional men. The greatest number of rails unloaded, curved and reloaded at the Chattanooga plant in any one day was 130. This was when the rails were received on flats and neatly stacked thereon in layers with separator sticks. The average day's work from flats not loaded in this manner should be about 100 rails. When rails are received in high-side coal cars, about 75 rails is an average day's work. Using the above averages and including gasoline, oil, etc., the cost per rail unloaded from flats should be 12½ cts.; when unloaded from coal cars, 17½ cts. The average cost of over 3,000 rails curved by the Chattanooga machine was about 20 cts. per rail. These were nearly all received in high coal cars, and the work was done at different times, causing frequent use of inexperienced men. This, however, even above the figured cost, effected a saving of 23 cts. per rail over the hand method, and, in this lot alone, representing less than 35 miles of road, nearly paid for the plant, besides being of inestimable value in time saved to the track-laying force.

The construction described is rude, and was put together hurriedly for an experiment. It is evident from the different costs per rail that the weak point is in the unloading. Were another plant constructed, a few changes in driving gear and the use of an engine with compressor for pneumatic hoists on the cranes would be recommended. With this arrangement, six men and a foreman could easily operate it; and the cost per rail would, doubtless, be reduced to 10 cts., whether loaded on flats or coal cars. The usefulness of this arrangement for rail curving might be still further promoted by mounting machinery on a flat car and handling rails with rail loaders operated by air from the bender's engine. In this form it could readily be transferred from place to place, and would possibly be a valuable acquisition to a railway contractor's outfit.

CONTRIBUTIONS TOWARD A NEW TECHNICAL LIBRARY FOR SAN FRANCISCO ENGINEERS.

The following are among the responses received to a circular letter suggesting contributions by publishers of technical books of their own publications to the new technical library for the engineers of San Francisco, referred to by Mr. Von Geldern on p. 584 of our last week's issue:

We will consider Mr. Von Geldern's request for donations to the technical library for the San Francisco engineers.

Yours very truly,
Spon & Chamberlain.

New York, May 24, 1906.

Answering your circular letter of May 22, concerning the San Francisco engineer's library, would say that we have already taken this matter up with them and made arrangements to furnish our own publications.

Yours very truly, Hill Publishing Company.

New York, May 25, 1906.

In reply to your letter of May 23, we beg to say that we shall be very glad indeed to endeavor to arrange that the San Francisco booksellers shall sell our publications to the San Francisco engineers at a special rate for a limited time in view of the loss by the San Francisco engineers of their technical and reference libraries. Yours very truly,

The Macmillan Company.

New York, May 24, 1906.

We have your letter of the 23d, giving further details regarding the very commendable work which you are doing to assist the engineers who suffered loss in the San Francisco fire, in the establishment of a library of technical books, to meet their immediate and pressing needs. The plan meets with our hearty approval, and we have already advised Mr. Von Geldren, who had written us on the same subject, that we would take pleasure in co-operating with others by supplying one copy each of all of our technical books and various bound volumes of our periodicals, making a total contribution of about $300. Yours very truly,

McGraw Publishing Company.

New York, May 24, 1906.

In addition we may note that the firm of D. Van Nostrand Co. has arranged to contribute its own publications to the value of $250 to the proposed library.

A NEW DRAWING STAND.

The folding drawing stand herewith illustrated will be of interest, we are sure, to engineers who want a portable draftsman's outfit for use in camp, as well as to those who desire to economize office space and would be glad to have the room which the ordinary drawing stand takes up when not in use. The trestle illustrated is made of light iron tubes, which telescope into each other and are held in position by thumb screws, thus making adjustment of height or position of board a very simple matter. The spread of the frame is such that, together with its bracing, due to the form of construction, the trestle is very rigid. When folded as in Fig. 2 it makes a package only 3 ins. thick. The stand has a range in height of 29½ to 48 ins. above the floor, and is made in sizes to take boards 19½ × 20½ ins. to 36 × 60 ins. or larger.

The telescope legs permit the top to be set level or at any desired slope, and the trestle will stand firm on an uneven floor or on the ground in a tent.

The trestle is manufactured by Williams, Brown & Earle, 916 Chestnut St., Philadelphia.

A FIVE-MILE TUNNEL is to be built on the New Zealand Government railways, and bids for its construction are being received by the Public Works Department. It will be known as the Arthur's Pass tunnel, and will pass beneath the Southern Alps about 80 miles north of Christchurch. A notable feature is that the tunnel is to be driven on a uniform grade of 3% from portal to portal. The time of completion is fixed at five years, but alternative bids for completion in four years will also be received.

A 2-FT. GAGE RAILWAY, 100 miles long, is to be built in Natal, South Africa, as part of the Government railway system. It is to extend from Esperanza to Donnybrook, and will have maximum grades of 3% and curves with a minimum radius of 175 ft. The whole work, including the final survey, construction, equipment and working for two years after completion, was let on Nov. 29, 1905, to Pauling & Co., for £292,500, equivalent to about $14,500 per mile.

A LABORATORY for making physical and chemical tests of cement, sand, stone, metals and other building materials, soils, etc., has been established by the Board of Water Supply of New York City at No. 147 Varick St. The force connected with the laboratory is also engaged upon field explorations for suitable building materials along the line of the works, and may make tests of various kinds of plain and reinforced concrete construction, and other tests which will be useful in determining difficult problems of design. Mr. Ernst F. Jonson, Assoc. M. Am. Soc. C. E., as Engineer Inspector, has general charge of the work; Mr. James L. Davis, Assistant Engineer, is in charge of the physical laboratory and the connected field work; Mr. Richard H. Gaines is chemist, and Mr. Alfred D. Flinn is Engineer of Headquarters Department, to which department this work is assigned. Trade publications regarding construction materials will be gladly received at the laboratory for the reference file.

A TRIAL OF WATER METERS in selected districts is to be made by the water department of New York City under an enabling legislative act just signed by Governor Higgins. The meters are to be placed without

Fig. 1. Ready for Use.

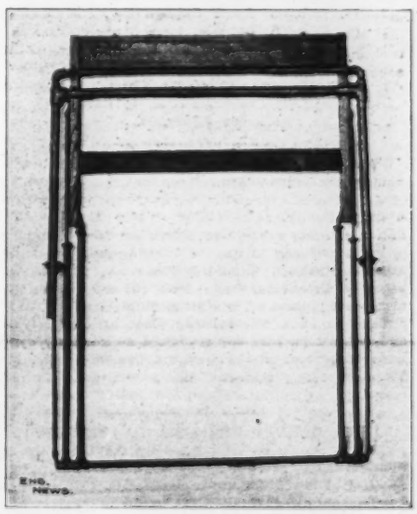


Fig. 2. Folded.

A TELESCOPIC FOLDING ADJUSTABLE DRAWING STAND.
Williams, Brown & Earle, Philadelphia, Makers.

expense to the consumer, read frequently, and a report on the results of the trial, accompanied by recommendations, is to be made to the Board of Estimate and Apportionment not later than Jan. 1, 1907.

AN IMPROVED STREET PLAN for San Francisco is reported as assured, according to an Associated Press interview with Mr. D. H. Burnham, of Chicago. In our issue of May 10, 1906 (p. 519) we commented on the fortunate fact that, through the previous studies of Mr. Burnham, San Francisco had, immediately after its earthquake and fire, a plan for rebuilding on improved lines. On request, Mr. Burnham has visited San Francisco, since the disaster, and conferred with the authorities on modifications in his plans, made desirable, or in some cases for the first time made feasible, by the ruin of the city. Mr. Burnham is quoted as saying:

> The plans were adopted in their entirety at a meeting on Monday [May 21]. The principal talk in San Francisco at the present time is of rebuilding. The pride of the citizens appears to have been touched by the disaster, and even the poorer people who lost their homes are preparing to build again on a more substantial and artistic scale. My views were chiefly desired along the line of modifications or extensions in the plans that I suggested for the streets and parks. I was asked for suggestions also as to public buildings, and recommended that they all be made strictly fireproof. The new city will radiate from the City Hall and that locality. One of the beneficial effects of the earthquake was the destruction of the old City Hall, an incongruous structure that could not be made to conform to any possible system of plans for the beautification of the city. San Francisco of the future will be the most beautiful city on the continent, with the possible exception of Washington.

THE RIGHT TO SPECIFY A CERTAIN PAVING cement, even though the material is controlled by one company, has been approved by one of the lower courts of Indiana. The action is justified, it is held, because there existed an agreement between the city and the company controlling the cement to the effect that the latter would sell to any other contractor both the cement and the patent right to construct pavements making use of it at the uniform rate of 90 cts. per sq. yd. The suit in question was brought by an individual against the city of Indianapolis to prevent the carrying out of a contract between the city and the Hoosier Construction Co. for the improvement of State St. with Warren's bitulithic pavement. In his review of the case the judge stated that, so far as the evidence showed, the cement paving specified was better than any other available, and, assuming this to be actually true, it was better to specify the cement directly rather than by the indirect method of "any other as good." The city, the argument appears to run, is protected by the agreement to furnish the material and patent rights to any other contractor, particularly as the wearing surface is only a part of the contract work involved.

TRACK ELEVATION IN CHICAGO is to have important extensions, costing about $4,000,000, under an ordinance recommended by the council committee on track elevation. It will involve seven railways, starting at Stony Island Ave. and 79th St. and extending to the Indiana State line: Pittsburg, Fort Wayne & Chicago Ry., 4.3 miles (14.3 miles of track), 19 subways, $1,600,000; Lake Shore & Michigan Southern Ry., 4.5 miles (11.2), 19 subways, $1,500,000; Chicago & Western Indiana Ry., 2.5 miles (15), 11 subways, $600,000; Chicago, Rock Island & Pacific Ry., 1.25 miles (3.5), 11 subways, $600,000; Baltimore & Ohio Ry., 1.25 miles (3.3), 11 subways, $500,000; South Chicago Ry., 1.2 miles (6), 4 subways, $150,000; Chicago, Lake Shore & Eastern Ry., $20,000. The committee is now considering an ordinance for track elevation of the lines from Campbell Ave. to the drainage canal and of the Chicago, Burlington & Quincy Ry. from California Ave. to Robey St.; this is estimated to cost about $3,000,000.

CREOSOTED TIES for railway track are evidently coming into more general favor, as stated in the article on the Somerville creosoting works of the Atchison, Topeka & Santa Fe Ry. in our issue of May 3. The Northern Pacific Ry. has now placed orders for two tie and timber preserving plants, to use the Rueping creosoting process, and the Missouri, Kansas & Texas Ry. will convert its plant at Greenville, Tex., from the zinc-tannin to the creosoting process. The Gulf & Ship Island Ry. has also decided to build a creosoting plant at Gulfport, Miss., and for that purpose has organized an auxiliary company under the name of the Gulfport Creosoting Co., Mr. J. T. Jones being president of this as well as of the railway company.

RIVER GAGING STATIONS IN MISSISSIPPI and Louisiana are to be established by the U. S. Geological Survey, under the direction of Mr. W. E. Hall. The data are desired locally for use in connection with water power developments and with irrigation for truck farms. The stations thus far selected are as follows: On Tallahatchie River, near Batesville; on Yalobusha River, near Grenada, in northern Mississippi; on Homochitto River, near Rosetta, in southwestern Mississippi; on Tangipahoa River, near Amite, and on Bogue Chitto, near Warnerton, in eastern Louisiana. The establishment of additional stations will depend upon the finding of suitable points and upon the availability of funds to carry on the work.

AN UNUSUALLY PROSPEROUS WATER-WORKS plant, at Lyons Falls, N. Y., a village of 700 population has been brought to public notice by its recent application to the New York State Water Supply Commission for the approval of plans for a new and additional source of water supply. The village has been supplied for about ten years by the Beauty Spring Water Co., which was incorporated in June, 1896, with a paid-up capital of $3,000. The total expenditure on the plant, up to the beginning of 1905, was $11,117. This included the cost of the original construction and subsequent extensions, together with all taxes, maintenance and operating expenses. The total sum, except the original capital of $3,000, has been paid for out of the earnings, and in addition the earnings have sufficed for yearly dividends of 6% on the capital stock. This handsome showing was due to the fact that the village is founded upon rock of such a character that no water could be obtained from private wells, thus making every one dependent upon the water company. The chief industry of the village is the Gould Paper Mills, where the larger part of the adult male population is employed. The water supply is taken from a spring. About 675 ft. below the spring a head-box 10 × 40 ft. in plan and 2 ft. high, and at an elevation of from 100 to 250 ft. above the village, is located. About 2½ miles of wooden pipe, from 8 ins. to 1 in. in diameter, convey the water from the head-box to the several consumers. At times the pressure in the village has been inadequate. At the hearing held by the Commission the water company objected to proposed municipal ownership by the village. The village, however, had expressed its willingness to buy the works of the company under an agreement or at an appraised valuation. The Commission therefore decided that, inasmuch as there was nothing in law to prevent competition with the water company by any other company or individual, there was no reason why the municipality should not be authorized to provide works, and it therefore approved the plans laid before it.

THE GROSS VALUE of the mineral products of the Province of British Columbia for the year 1905 was $22,461,325, an increase of $3,483,966, or 18.4%, over the preceding year. An analysis of the returns shows, however, that this increase has been confined to certain districts, the remaining districts showing a more or less marked decrease.

The total tonnage of ore mined, exclusive of coal, was 1,706,679 tons, some 245,070 tons, or 16%, increase over 1904. The gross output of the coal mines for the year was 1,825,832 long tons, which, with 314 tons taken from stock, gives a total production of 1,826,146 long tons. Of this total amount 1,202,971 tons were sold as coal, 441,520 tons were used in making coke, and 181,655 tons were consumed under the companies' boilers or sold locally. The coal sales to the United States for the year was 53% of the total sales, exactly the same as in 1904.

The production of placer gold for the year was $969,300, a decrease of some $146,000, or 13%, as compared with 1904, while the output of gold from lode mining was $4,933,102, an increase of $343,494, or about 7½%, over 1904.

The total silver production was 3,439,417 ounces, valued at $1,971,818, the largest output since 1901. About 70% of the silver produced was found associated with lead, in argentiferous galena, the remainder being chiefly in conjunction with copper ores.

Some 56,580,703 lbs. of lead, valued at $2,399,022, were mined in 1905. This is an increase of 19,934,459 lbs., or about 54%, over the preceding year.

The output of copper increased 1,982,123 lbs., or about 5½%, over the preceding year, the total production being 37,692,251 lbs., valued at $5,876,222.

No iron ore was mined in the Province, as there was no market available, while for the first time important sales of zinc ore were recorded. Approximately 9,413 tons of zinc ore, or zinc concentrates, were sold, having a value at point of shipment of about $139,200.

PERSONALS

Mr. James G. Lindsay, architect and civil engineer, of Belfast, Ireland, has been appointed City Engineer of Guelph, Ont., to succeed Mr. James Hutcheon.

Senator Edwards and Mr. A. P. Caron have been elected Directors of the Central Canada Railway Co.

Mr. John Stewart, for the past 10 years Construction Engineer of the Dominion Bridge Co., Montreal, Canada, has been appointed Commissioner of Irrigation for the Provinces of Alberta and Saskatchewan. This office has but lately been created by the Department of the Interior of Canada, and Mr. Stewart is the first person to fill the position. His headquarters will be at Calgary, Alberta, Canada.

Mr. R. S. Corey has resigned from the Engineering Department of Salt Lake City to accept the position of Civil Engineer, Utah Light & Railway Co.

Mr. A. L. Hartridge has resigned as Assistant Engineer, Ocean Shore R. R., at Colma, Cal., to become Assistant Engineer of the Sonora R. R. at Naymas, Mexico.

Mr. Robert E. Horton, for several years in charge of hydrography in the eastern part of the United States, with headquarters at Utica, N. Y., will sever connection with the U. S. Geological Survey on June order to study special hydraulic problems connected with the New York barge canal.

The following changes have taken place in the Reclamation Service: Mr. C. G. Ranney has been appointed Assistant Engineer and assigned to Lower Project; Mr. A. M. Springer, Engineer, has been reinstated in the Service and assigned to duty on St. Mary Project, Mont.

Mr. J. C. Avakian, Assistant Engineer in the California Division of the Reclamation Service, has been granted indefinite leave of absence to begin private engineering work in Los Angeles, Cal.

Mr. LeRoy L. Hunter has been appointed Assistant Engineer of the Atchison, Topeka & Santa Fe Ry.'s track elevation work at Joliet, Ill.

Mr. Rudolph P. Miller, M. Am. Soc. C. E., has resigned as Chief Engineer of the Bureau of Buildings, Borough of Manhattan, New York City. His resignation was made necessary owing to his poor health, and takes effect June 1.

Mr. Benjamin M. Ray has been appointed Inspector of Engines and Boilers in the New York State Steam Vessel Inspection Service, which is under the jurisdiction of the Superintendent of Public Works. He succeeds Mr. George B. Preston, resigned.

ENGINEERING SOCIETIES.

COMING MEETINGS.

NATIONAL ELECTRIC LIGHT ASSOCIATION.
June 5. Annual meeting at Atlantic City, N. J. Secy., W. C. L. Eglin, 136 Liberty St., New York, N. Y.

AMERICAN FOUNDRYMEN'S ASSOCIATION.
June 5 to 7. Annual convention at Cleveland, Ohio. Secy., Richard Moldenke, Watchung, N. J.

MASTER CAR BUILDERS' ASSOCIATION.
June 13. Annual convention at Atlantic City, N. J. Secy., J. W. Taylor, 658 Rookery, Chicago, Ill.

AMERICAN RAILWAY MASTER MECHANICS' ASSOCIATION.
June 18. Annual convention at Atlantic City, N. J. Secy., J. W. Taylor, Old Colony Bldg., Chicago, Ill.

AMERICAN SOCIETY FOR TESTING MATERIALS.
June 21-23. Annual meeting at Atlantic City, N. J. Secy., Edgar Marburg, University of Pennsylvania, Philadelphia, Pa.

AMERICAN SOCIETY OF CIVIL ENGINEERS.
June 26. Annual convention at Thousand Islands, N. Y. Secy., Chas. Warren Hunt, 220 West 57th St., New York, N. Y.

SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION.
June 29 to July 4. Annual meeting at Ithaca, N. Y. Secy., M. S. Ketchum, University of Colorado, Boulder, Colo.

AMERICAN WATER-WORKS ASSOCIATION.
July 10 to 14, inclusive. Annual meeting at Boston, Mass. Secy., J. M. Diven, 14 George St., Charleston, S. C.

AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS.
July 19 to 20. Semi-annual meeting at Chicago, Ill. Secy., W. M. Mackay, P. O. Box 1818, New York City.

AMERICAN INSTITUTE OF MINING ENGINEERS.
July 23 to Aug. 4. Joint meeting with the Iron and Steel Institute at London. Secy., R. W. Raymond, New York City.

AMERICAN FOUNDRYMEN'S ASSOCIATION.—The eleventh convention of the association will be held at Cleveland, O., June 5 to 7. The meeting will be held in the Armory, except on Thursday, June 7, when the last session of the convention will be held upon a steamer, during an excursion on Lake Erie. The subjects of the addresses and papers to be presented before the convention are: "The Need and Benefit of a Practical Education"; "The National Bureau of Standards and Its Work"; "Influences of Different Ore Mixtures on the Resultant Pig Iron, from the Standpoint of the Foundryman"; "The Beneficial Effect of Adding High Grade Ferrosilicon to Cast Iron"; "Notes on Laboratory Investigation of Wisconsin Molding Sands"; "Recent Methods of Machine Molding"; "A Plea for Lower Blast Pressures in Cupola and Air Furnaces"; "The Electric Crane in the Foundry"; "Twenty Years' Improvement in the Quality of Pig Iron"; "Good Molders, Why Are They Scarce?" "A Modern Pipe Foundry"; "New Tendencies in General Foundry Management"; "Uniform Practice in Foundry Cost Finding"; "Comparative Designs and Working of Air Furnaces"; "Core Binders"; "Experiments on the Strength of Various Cast Iron Machine Parts"; "Electricity in the Foundry"; "A Talk on Alloys"; "Toilet Rooms and Sanitary Appliances for the Foundry"; "The Manufacture of Soil Pipe and Fittings"; "Development of the Thermit Process in Foundry Practice"; "Molding Problems"; "Dark Secrets in the Foundry"; "Foundry Tests of Coke, Made at the U. S. Fuel Testing Plant in St. Louis"; several papers on Pattern-making, titles of which are not yet determined, besides typical discussions, if time allows.